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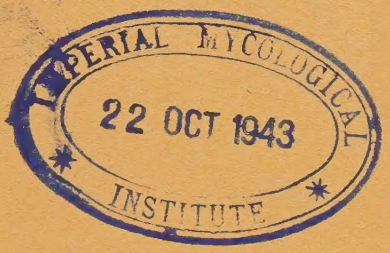
The Kent Incorporated Society for Promoting Experiments in Horticulture

ANNUAL REPORT

(THIRTIETH YEAR)

1942



EAST MALLING RESEARCH STATION

Near MAIDSTONE

KENT

1st January, 1942 to 31st December, 1942

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Published
August, 1943

THE KENT INCORPORATED SOCIETY
FOR PROMOTING EXPERIMENTS IN
HORTICULTURE

ANNUAL REPORT

(THIRTIETH YEAR)

1942

EAST MALLING RESEARCH STATION

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CONTENTS

PAGE

GOVERNING MEMBERS OF THE SOCIETY 5

MEMBERS OF THE EXECUTIVE COMMITTEE 6

STAFF 7

EDITORIAL 9

Section I

THE EXPERIMENTAL FARM

EXPERIMENTAL ORCHARDS—TOP FRUITS 11

SMALL FRUITS 11

EXPERIMENTAL NURSERIES 11

HOPS 12

ARABLE CROPS 13

ROUTINE SPRAYING PROGRAMME 13

Section II

GENERAL REVIEW OF RESEARCH WORK, WITH LISTS OF PAPERS PUBLISHED DURING THE YEAR

I. POMOLOGY 14

II. STATISTICS AND RECORDS 19

III. PLANT PHYSIOLOGY 20

IV. BIOCHEMISTRY 21

V. PLANT PATHOLOGY 22

VI. ENTOMOLOGY 24

VII. INSECTICIDES AND FUNGICIDES 25

VIII. HOPS 27

IX. TECHNICAL SECTION 30

Section III

RESEARCH REPORTS

POMOLOGY

Five New Raspberry Seedlings. N. H. GRUBB 31

Weather Conditions during 1942. H. C. CHAPELOW and H. M. TYDEMAN 33

STATISTICS AND RECORDS

An Investigation into Means of Reducing the Labour needed for Recording Crops. S. C. PEARCE 36

PAGE

PHYSIOLOGY

The Propagation of Fruit Tree Stocks by Stem Cuttings. III. Further Observations on Hardwood Cuttings. M. C. VYVYAN 40

Sprays to Control Pre-harvest Drop of Fruit. M. C. VYVYAN 47

PLANT PATHOLOGY

A Leaf Curl Disease of Raspberry in Scotland. R. V. HARRIS, A. D. BRYCE and C. E. FOISTER 48

Sun Scald of Fruits. M. H. MOORE and W. S. ROGERS 50

A Field Trial of Measures designed for the Control of Bacterial Canker of Victoria Plum Trees. H. B. S. MONTGOMERY, M. H. MOORE and T. N. HOBLYN 53

Bacterial Diseases of Acid Cherry Trees. H. WORMALD 61

A Phytophthora Disease of the Hop in Great Britain. W. G. KEYWORTH 62

ENTOMOLOGY

Notes on Some Interesting Insects Observed in 1942. A. M. MASSEE 64

INSECTICIDES AND FUNGICIDES

Field Trials on Phenyl Mercury Chloride for the Control of Potato Blight. H. B. S. MONTGOMERY and H. SHAW 68

HOPS

Cultural Trials with Hops. III. The Effect of "Stopping" and Number of Bines per String on a Vigorous Late Variety (OV7). F. H. BEARD 70

A Comparison of the Performance of Sets and Cuts of Hops when Planted in their Permanent Positions. F. H. BEARD 73

Commercial Varieties of Hops: A Preliminary Comparison of their Chief Characteristics at East Malling. F. H. BEARD 75

Section IV

BULLETINS FOR FRUITGROWERS

Raising Rootstocks. R. J. GARNER 84

Fruit Planting Policy with Special Reference to Quality of Material. R. G. HATTON .. 90

The Value of a Fruit Farm Census. T. N. HOBLYN 93

The Production of Fruit from Four Experimental Apple Plantations at East Malling, 1920-42. T. N. HOBLYN 96

Plants and their Water Supply. W. S. ROGERS 103

Some Fruit Diseases seen on Survey in Kent. H. B. S. MONTGOMERY and M. H. MOORE .. 104

A Note on Apple Sucker. A. M. MASSEE 107

The Merits of the New Varieties of Hops. E. S. SALMON, F. H. BEARD and R. G. HATTON .. 108

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Experimental Greenhouses : A. TIDY.

Meteorological Records : H. C. CHAPELOW.

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All *correspondence* should be addressed to East Malling Research Station, near Maidstone, Kent.

Visits may be paid on any weekday, *by appointment* if possible (Saturday afternoon under exceptional circumstances only).

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Telephone : Aylesford 7294 (2 lines). *Telegrams :* Research, East Malling

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Accommodated at Bradbourne, the Administrative Headquarters of the East Malling Research Station

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EDITORIAL

The pressure of other work has again caused delay in the publication of our Annual Report, but, as last year, it has enabled us to give a more complete account of the year's work on the Experimental Farm, and to bring up to date the changes in Staff. In the latter connection attention is called to the changes shown in the regrouping of those members of staff attached to the Plant Pathology and the old Insecticides and Fungicides sections. It will be noted also that Mr. Bagenal has been seconded to Ministry of Food and that the Technical Section is at present in the charge of Dr. Montgomery.

As in past years we again include a number of Bulletins for Fruitgrowers (Section IV), but growers will find that there are articles in the Research Reports (Section III) that have a direct practical bearing.

The important features only of the year's research work are set out in Section II, and only those summaries of papers published in other journals have been included which record important stages in our work.

Mr. Bagenal and Dr. Montgomery have helped in assembling Section IV. The heads of Sections are responsible for the Sectional Reports, and the general editorship has again been undertaken by Dr. Wormald.

R. G. Hatton.

August 1943.

Section I

THE EXPERIMENTAL FARM

Contributions from J. AMOS, F. H. BEARD, R. J. GARNER, D. H. HAMMOND, R. G. HATTON, T. N. HOBLYN and H. B. S. MONTGOMERY

Taking all fruits into consideration the 1942 yields were the heaviest in the Institute's history. The season was a fairly late one and only one severe ground frost was recorded, on 3rd May; even then the temperature in the screen fell only to 29° F. Strong north-east winds were again prevalent, particularly during the early part of the blossoming season.

Experimental Orchards.—Top Fruits.—*Apples.*—The total crop off 50 acres was 13,500 bushels, which has only once been exceeded (15,200 bushels in 1939) since many of our plantations were severely thinned. Bramley's Seedling, of which we have approximately 9½ acres (660 trees) under various experimental treatments, averaged 5½ bushels per tree, but on our rootstock trial the yield was heavier, averaging 8 bushels per tree on all rootstocks. This is the heaviest crop *per tree* so far but does not yet reach the heaviest *acreage* yield before the plantations were thinned. Those trees which were frame-worked in 1940 to Grenadier to provide pollinators gave 5½ bushels per tree. The 4½ acres of Lane's Prince Albert (800 trees), after severe cutting up and spur thinning, averaged 490 bushels per acre, or 2¾ bushels per tree of fine quality fruit, despite the absence of fruit thinning. Worcester Pearmain produced good crops for the fourth year in succession, the rootstock trial orchard yielding 3¼ bushels per tree. The areas of Cox's Orange Pippin under various rootstock, manuring and spraying trials produced their heaviest crop since 1940. Barnack Beauty, of which we have one acre (170 mature trees), exceeded their previous crop of 530 bushels in 1940 and once again gave the heaviest yield per acre—575 bushels.

Pears.—Off 7 acres of mixed varieties (approximately 1,700 trees) 2,595 bushels were harvested. Of this total, which is the heaviest crop to date, one acre of Conference (270 trees) produced 600 bushels, and 400 trees of Dr. Jules Guyot—of which at least half are on free pear rootstocks and had been severely dehorned recently—gave 500 bushels.

Plums.—The crop of 9,000 halves off 14½ acres was the second heaviest yet produced. It is probable that the strong north-east gales during blossoming materially reduced the crop of Victorias which even then amounted to 2,286 halves. The Red Cherry Plum windbreaks (268 trees) produced 860 halves. The 3 acres of Giant Prune (500 trees) gave nearly 7 halves per tree. This was their fourth heavy crop in succession. Warwickshire Drooper, after an off year in 1941, gave about 6 halves per tree. Both Rivers' Early Prolific and Cambridge Gage averaged 5 halves per tree. The collection of high quality gages frameworked on to Czar nearly all cropped for the second time in three years.

Cherries.—One hundred and forty trees of Kentish Red yielded 670 halves, which was nearly double the best previous crop. An acre of Morellos (240 trees) gave 630 halves. We now have rather more than 12 acres planted to sweet cherries at 30 feet square (650 trees), most of which are still interplanted with plums. Most of the cherries are about 15 years old, though they vary from 3 to 22 years in the variety collection, and they produced their first crop of 1,200 halves in 1942. A severe attack of bacterial dieback began to manifest itself in the branches of the Early Rivers trees in the autumn. Half the area was laid down to grass and clover mixture to see whether this had any mitigating effect upon the disease.

Small Fruits.—*Strawberries.* Our fruiting area of M35 Royal Sovereigns amounted to 6 acres. At least 25% of the early blossom was killed by the frost of 3rd May and the crop was further curtailed by a drought in early June—with the result that we harvested just under a ton per acre.

Raspberries, Loganberries and Blackberries.—About an acre of new seedling raspberries yielded approximately 2 tons of good quality fruit. About ¾ acre of our clonal loganberries gave 1½ tons. Winter injury two years in succession had severely reduced the cane growth during 1941, and probably also resulted in much root killing. This accounts for the low crop in 1942.

Black Currants.—Off 4 acres of mixed varieties we marketed 6¼ tons, the bulk of which came from 2 acres of Baldwin and Triple X which gave over 2½ tons per acre. The other varieties, Boskoop Giant, Seabrook's Black and Goliath, all "ran off" very badly owing to the cold winds at blossoming time.

R.G.H., T.N.H. and J.A.

Experimental Nurseries.—There were some 27 acres occupied by experimental nurseries during 1942, of which 12 acres were stoolbeds and 10 acres strawberries. The area under stoolbeds was increased to 17 acres at the end of the year by the completion of the new 10 acre stoolbed on the Bradbourne land. The first 3 acres of this were planted in the spring of 1941 and have now yielded a first crop of some 40,000 rootstocks. A further 2 acres were planted in the spring of 1942 and the remainder during the winter 1942-3. As the new beds come into bearing we shall be bound to grub

up the old ones because of the amount of hand labour involved. Even an area of 10 acres should be sufficient to affect the home supply of rootstocks markedly, as in another three years when in full production, it should have an annual output of half a million rootstocks. The total crop of rootstocks from the 7 acres of older stoolbeds totalled seven hundred thousand. This record quantity was achieved by the sale of second grade rootstocks for bedding, in addition to the usual crop of first size one-year layers and bedded material. The distribution of seconds has released ground usually occupied by bedded rootstocks and has enabled nurserymen to acquire rootstocks in advance. It is hoped that some at least of these, after bedding, will be used for further propagation.

One of the chief new activities during the year has been the extension of the nuclear stock scheme to black currants, raspberries and loganberries. From a small beginning with healthy clonal material we raised during the season an acre of one-year-old black currant bushes which made excellent growth. At the end of the year the cuttings from these were set out on a further half acre of land. When the present bushes are two years old there will be sufficient cuttings for the 2 acres asked for by the Ministry of Agriculture. These may be expected to yield forty to fifty thousand healthy true-to-name bushes each year. It was planned to plant rather less than 1 acre of the proposed 2 acre raspberry nursery in the spring of 1943.

The loganberry nursery has been extended to one acre. Two thousand bedded plants were distributed from the smaller parent nursery.

Ten acres of M40 Royal Sovereign strawberry plants were grown under the nuclear stock scheme, and this area, with 8 acres in daughter nurseries, yielded close on a million runners. A new bed of 8½ acres was planted at the Research Station in October and seven daughter nurseries made fresh plantings amounting to nearly 20 acres in all.

Various experimental tree nurseries covering one acre were maintained.

Part of the lake at Bradbourne, now drained, has been planted with cuttings and is proving useful for experimental work.

The establishment of nuclear stocks of small fruits and the rapid expansion of our stoolbed area has entailed much extra work and we were very fortunate in having open weather during the autumn and winter of 1942-3. R.J.G. and D.H.H.

Hops.—The total acreage remained unchanged at 9 acres. A further 30 short rows of seedling varieties now superseded have been grubbed, and the area under new varieties undergoing their preliminary trial is now just under 3 acres. The ground made vacant by this grubbing has been planted with larger blocks (135 hills approximately) of four varieties of merit, Fillpocket (Z62), College Cluster (N15 bis), Brewer's Stand-by (HH44) and OH44. The ½ acre of P13 is being gradually replaced by Malling Midseason (BB28) and Early Promise (X35).

The season was on the whole favourable to the growth of hops and in consequence the yields of most of the varieties were well above those of 1941. Our total growth amounted to slightly over 6¼ tons, but about 3 acres were not in full cropping. The basal spike form of Downy Mildew was almost absent, but there were numerous lateral, and a few terminal, spikes during the 2nd and 3rd week of June. The usual routine Bordeaux spraying was given and the cones of all varieties were free

Variety.	1941.		1942.	
	Ordinary Valuation.	Valuation on P.V. Basis (10α).	Ordinary Valuation.	Valuation on P.V. Basis (10α).
	£ s.	£ s.	£ s.	£ s.
Nonsuch Hop (OB53)	—	19 10	—	27 10
Brewer's Gold (C9a)	16 10	—	19 0	24 6
Bullion Hop (Q43)	16 10	—	19 0	23 18
Brewer's Favourite (OP21) ..	16 10	—	18 5	24 16
Quality Hop (0063)	16 10	—	18 5	20 17
Fillpocket (Z62)	16 10	—	18 5	14 16
College Cluster (N15 bis)	—	18 10	—	18 15
Brewer's Stand-by (HH44) ..	—	17 10	—	26 14
Malling Midseason (BB28)	—	—	—	25 10
Fuggle Strain A	—	14 0	—	17 12
Fuggle Strain L	—	14 15	—	17 6
Fuggle Strain N	—	13 10	—	16 8
Fuggle (A.L.N.)	15 0	—	17 15	—
Mixed Growths	14 10 to 15 0	—	17 0 to 17 5	12 12 to 15 18

All prices per cwt.

from attack. In the early part of the season the aphis attack was not severe, but a late infestation caused the cones of some varieties to be " blighty ". Picking lasted 23 days and the bulk of it was done under good conditions, but at the end extremely wet weather made the work very difficult. Valuations placed on the 1941 and 1942 growths are given below. In both seasons pockets of certain growths were bought by a well-known firm of brewers and valued on a P.V. (10x) basis, and in 1942 pockets of the same varieties were valued on both the P.V. basis and the usual physical examination, and provide an interesting comparison. F.H.B.

Arable Crops.—Some 69 acres were available for the production of primary food crops.

Potatoes.—Twenty-four acres—4 of Eclipse and 20 of Majestic averaged just under 10 tons per acre.

Cereals.—Fifteen acres of Als wheat were sown. The 5 acres already threshed have yielded just over 8 quarters per acre. The variety is stiff strawed and stood well.

Twenty-four acres of Plumage Archer barley—December sown—gave just over 6 quarters per acre. This area was undersown in spring with seeds. Six acres of Victory oats yielded 50 quarters.

At Michaelmas we took over the remaining 100 acres of Park Farm, Bradbourne, and approximately 160 acres of open land became available for planning a four-course rotation. R.G.H. and J.A.

Routine Spraying Programme.—The programme closely followed that recommended in the 1942 Spray Calendar with modifications as necessary.

The winter washing was begun early in December and most of the tar-oil spraying was finished before the severe frost in January and February. The apple trees on Kiln Field were left unsprayed until the beginning of March and were then sprayed with a D.N.C. petroleum wash diluted to give 6% actual petroleum oil. This is the second season that D.N.C. has constituted the sole winter wash on this plot and the control of pests was, with few exceptions, satisfactory. In the third week in March the apple plots, excluding Kiln Field, were sprayed with 5% petroleum oil to control capsid. Unfortunately the buds moved very fast after the long spell of cold weather and the trees were rather advanced when the last plots were sprayed. On one plot of Cox's (Plot 32) a number of buds were killed in the lower parts of the trees. Apart from this no other damage followed the use of this spray except that some very starved trees on the apple manurial trial failed to come into leaf and died back. The trial of new seedling black currants (Plot 27) also received petroleum to control Lygus capsid bug.

Since petroleum oil had been used on all plots, no lead arsenate was used in the pre-blossom sprays on apples. It was found that the caterpillar control achieved was excellent.

The short pre-blossom period of pears reduced the pre-blossom sprays to one of lime-sulphur at 2½%. This was followed after blossom by two of Bordeaux mixture at 4-6-100.

In view of the risk of spring frosts in this season, the strength of both the pre-blossom lime-sulphur sprays on apples was dropped to 1% to avoid the usual lime-sulphur injury to the rosette leaves. This injury does not appear to matter in normal years but the experiments of Miss Field, reported in last year's Annual Report, suggest that it may render the blossom more liable to frost injury. There were, however, no serious spring frosts in this season. The petal-fall lime-sulphur plus nicotine was seriously delayed by bad weather after several plots had been sprayed and it was finished much too late to have controlled Sawfly on the last plots. Sawfly attack on these plots (mainly plots of young trees) was, fortunately, slight. A second post-blossom lime-sulphur at ¾% was applied, but hot dry weather led to the dropping of the third. Instead, on certain plots, mainly of Bramley's and Worcester, a colloidal sulphur (5 lb. to 100 gallons) was added to the lead arsenate applied against Codling at the end of June. Scab control was reasonably good though not perfect. Apple blossom weevil again defied our efforts to control it on cordons and other small apple trees in spite of derris powder applied at the recommended time.

The strawberry propagation plots were dusted with sulphur three times during the season, in May, July and August.

As the weather conditions were unfavourable for the spread of bacterial leaf spot on plums, no special spraying was made on the young plum trees. Young cherry trees, however, were given a routine spraying of Bordeaux mixture 6-9-100 just pre-blossom and 10-15-100 in the autumn. Bacterial blight on young walnuts was dealt with by Bordeaux mixture 6-9-100 applied twice during July.

Aphis attack on the hops proved difficult to control and three sprayings of nicotine and soap were made during June and July. Various troubles with the hop-washing machine affected the efficiency of some of these sprays and the last application was made with a reconditioned wheel-actuated machine, and this machine was also used for the two applications of Bordeaux mixture (10-15-100) to each of which nicotine was added. There was no need for a third Bordeaux spray in this season.

No derris was used on either raspberries or blackberries as there was little raspberry beetle on these hosts. Loganberries were, however, sprayed with lonchocarpus during the third week of June. Nicotine and soap was used to deal with an attack of aphis on the blackberries early in June.

H.B.S.M.

Section II

GENERAL REVIEW OF RESEARCH WORK

WITH LISTS OF PAPERS PUBLISHED DURING THE YEAR

I. POMOLOGY

By R. G. HATTON and W. S. ROGERS

A.—Tree Fruits.—Rootstocks.—Minimum essential records have been maintained on the field rootstock trials of apples, pears, plums and cherries. Trees in the oldest apple rootstock trials, in their 25th year, still show good growth and cropping, and there is no sign of senescence on any stock, including the most dwarfing. Younger trials also, with different varieties on different soil types, continue to provide information of great value for advisory work on future planting.

Some new apple rootstocks, bred for immunity from Woolly Aphis, and also showing a considerable range of vigour, have been sorted out for further trial, worked with the variety Lane's Prince Albert.

Selections from another series of stocks, produced by crossing various " Paradise " apples, all with No. IX as one of the parents, though not immune from Woolly Aphis, show possible superiority in some respects to the existing Malling series. They all root readily, and a three-year nursery trial has shown some to be more dwarfing than No. IX, and at least one more vigorous than No. XII. A field trial of these stocks, worked with Cox's Orange Pippin, has been laid out.

Continuing the study of the correlation between stock root structure and vigour and cropping of the scion, a detailed examination is being made of the anatomical structure of the roots of 38 of these new clonal rootstocks budded with Cox. The study of the recip:ocal effect of scion upon rootstock has been carried further by making sections of three apple rootstocks budded with three scion varieties ; and the possible effect of soil upon the anatomical structure has been examined by sectioning five apple rootstocks grown on four different soils. Methods of identification of rootstocks by their anatomical structure are being further developed.

The sweet cherry rootstock trials bore their heaviest crop so far. In the variety Turkey Heart there are indications that weight of crop, and possibly fruit size, are affected by the rootstock, apart from its effect on size and vigour. In the varieties Early Rivers and Bigarreau de Schrecken, however, severe attacks of bacterial canker interfered with stock comparisons.

The Kentish Red trees on various Mazzard stocks bore their heaviest crop ; the average for the whole trial (trees 15 feet apart) being about 130 lb. per tree. In general, as in previous years the larger trees bore the heavier crops ; however, trees on certain Mazzard selections produced heavier crops than might have been expected from the size of the trees.

Testing and selection of new seedling plums, pears, and quinces likely to make good rootstocks are being continued.

Trials of Czar and Victoria plum on new rootstock selections are now coming into full cropping. In other trials the effect of rootstocks and stem-builders upon incidence of Bacterial Canker is being studied (see VII. Insecticides and Fungicides). Observations on Silver Leaf incidence are also being made. In this connection a trial of fungicidal injections was carried out in collaboration with the Pathology and Biochemistry Sections.

Propagation. Nuclei of a number of rootstocks, still undergoing propagation tests, were maintained ready for multiplication as may be required.

Fifty-five of the new selected apple rootstocks immune from Woolly Aphis mentioned above were layered for the first time in their new quarters and their habit of growth and rooting were recorded. A number of them show promise as good propagators and after further test it should be possible to select a few of outstanding merit.

In a new trial of plum rootstock cuttings, the importance of source of material, as wel as later environment, was again demonstrated. Hardwood cuttings of Myrobolan B, taken from an established hedge and planted in October, 1941, in a one-time lake bottom and in a plot of Malling soil, showed 57% and 44% rooting respectively ; but hardwood cuttings taken from side shoots of a layer bed and grown in ordinary soil only rooted 16%. (See III. Physiology.)

A paper on vegetative propagation of plum rootstocks by layering was published (E185). (See III. Physiology.)

Re-working, Frameworking, etc.—Three papers describing experiments with different frame-working methods were published (Eg 22, 23 and 24).

The value of frameworking as a method of rapidly providing pollinators in orchards where these are lacking, owing to thinning of trees or other causes, was shown in a paper delivered to the Horticultural Education Association, and prepared for publication. This method has been used successfully in several of the Research Station plantations, and in those of nearby growers ; and many county officers have now arranged to demonstrate it in their own areas. A Growers' Bulletin giving illustrated instructions on frameworking, top-working, bridge-grafting, and inarching established trees wa published (Eg25).

Manipulation of incompatible combinations.—The trees of Williams' Bon Chrétien, double- and single-worked on quince, planted in 1940-1 were successfully bridgegrafted and inarched. After one season's growth there we e no measu able differences traceable to the manipulation. Similar trees of Williams' Bon Chrétien on Quince bridged with Fertility in 1938 and planted on a local fruit farm, made good growth during 1942. Many of the Fertility bridges are now thicker than the bridged Williams' stems.

Cover-cropping and grass orcharding.—Further valuable observations were obtained on a wide range of orchard cover crops, including annual crops, short-term leys, and semi-permanent grass and clover swards. It is clear that there are great differences between various crops, not only in tolerance of orchard routine, but in amount of green matter produced and in effect upon the tree and its fruit. Already it appears that certain grass swards, though greatly improving the fruit colour of Worcester Pearmain, have too severe a checking effect upon the growth of ageing trees. Annual crops, sown in autumn or spring, and turned in before the summer, have shown no such check, however, although producing large amounts of green material. The importance of correct adjustment of fertilizers for grass swards, especially nitrogen, is evident.

Trials of effect of different kinds of nitrogenous manure, and different times of application, upon the clover in mixed cover crop swards have been started, and further trials of time of sowing of certain annual cover crops in relation to damage by tar-oil and D.N.C. washes have been carried out.

Two of the short-term leys became due for ploughing-in in 1942. The opportunity was taken to study the root distribution of plants of ryegrass, red clover, lucerne and natural weeds (mainly *Poa*) by a soil-block-washing method.

The data of three years' work on the cover crops are being collected for a report.

Inorganic fertilizers.—In a trial of residual effect of previous dressings of potash no marginal leaf scorch appeared in 1942 on apple trees which have had no potash for three years, but had received 4 cwt. per acre of sulphate of potash in each of the preceding five years. Some interveinal leaf scorch appeared, especially on plots which had previously receiv ed high potash dressings. A small magnesium sulphate trial is in progress. The long-term N.P.K. trial of apples has been continued.

Soil moisture and irrigation.—Records were made with soil moisture tensiometers on a number of different cover crop plots. A script on " The plant and its water supply " was broadcast and later published (P7). This included simple directions for conserving soil moisture, and economical watering of plants. (See page 103.)

Pruning.—The logical development, from the fundamental principles, of pruning methods to suit trees of differing vigour and productiveness is being carried out, in collaboration with the Kent County Horticultural officers, on the rootstock trial plots established on different soil types in the county. Light pruning, including leaving a suitable proportion of laterals full length on well-spaced branches has proved strikingly successful in securing earlier cropping of trees in a vigorous state.

The attempts to control biennial bearing in Miller's Seedling apple by various pruning treatments have given rather inconsistent results mainly owing to the spring frosts of 1941. The control trees remain completely biennial, and still crop in the odd year (1939, 1941, 1943). Some treated trees remain almost as biennial as the controls and still crop in the odd year ; others have changed their year of cropping to the even year ; and a few show a definite tendency towards annual cropping. Two treatments are being repeated on a few trees not used in the first trial.

The Early Victoria apple trees drastically spur thinned (whole spurs removed) in 1941, yielded a heavy crop in 1942. Wide spacing of spurs achieved the object of the trial by giving a definite increase in fruit size, though at a cost of some reduction in total crop.

Low temperature injury to fruit blossom.—A paper (E188) on relative susceptibility of fruit blossom to low temperature injury, and the effect of environmental factors thereon, has been published. The stages and symptoms of injury were described. Flowers were most easily injured when in the green bud stage, but temperatures above 29° F. caused no injury. Humidity of the air had little effect on the damage, but wet flowers suffered more than dry ones. Glycerin spraying gave some resistance up to three days after treatment.

Winter injury to fruit trees.—Two papers on the injury caused to fruit tree branches and trunks by the severe winter frost conditions of 1939-40 were published (H41 and 42). The injury ranged from slight bark lifting to severe bark cracking, and in some cases to death of branches or whole trees.

Varieties and classification. Several apple and pear varieties of possible commercial importance have been frameworked on other trees.

Breeding.—Numerous apple and pear seedlings are now coming into cropping and the most outstanding have been selected for further trial. Search is being made for late flowering apples, likely to escape spring frosts, varieties resistant to Woolly Aphis, and high quality dessert maturing over as long a season as possible. As time permits, observations likely to shed light on the mode of inheritance of characters in apples and pears are being made.

B.—Small Fruits.—Classification, nomenclature and varieties.—*Raspberries.*—The cropping trial of two named varieties and seven seedlings, with five more seedlings in the guard rows, bore its first crop of fruit in 1942. Seedling "L" (34/42) was outstanding, with a yield over 50 per cent. higher than the next best. Amongst the nine varieties, Norfolk Giant came third and Baumforth B sixth.

There is likely to be a range of at least a week in time of ripening amongst the seven seedlings ; and this although neither the earliest nor the latest seedling so far propagated is included.

Short rows of several later seedlings produced some exceptionally fine fruit, in three or four cases the largest ever seen at East Malling. These have not yet reached the stage of large scale propagation, but several have already been sent to the National Fruit Trials at Wisley. (See also page 31.)

A paper on raspberry varieties (Esf 45) was published, giving the outstanding characteristics of varieties at present in cultivation and notes on their suitabilities.

Black Currants.—A variety and spacing trial was concluded. A Growers' Bulletin on "How to improve Black Currant Plantations" (Esf 46) was published. This stressed the importance of suitable and disease-free varieties, shelter, spacing, cultivation, manuring and spraying.

Loganberries and other hybrid berries.—Further information has been obtained on the best combination of training and spray treatment for the control of Cane Spot disease on loganberries and Phenomenal Berries. (See also VII. Insecticides and Fungicides.)

Strawberries.—In spite of damage to early blossom by frost, fair crops were picked. The superior vigour of Royal Sovereign M40 was again evident. A further repetition of the trial of various virus-free "susceptibles", including M40, Sir Joseph Paxton, and the original "Yellow-edge free" Sovereign M35, has been planted.

Further progress has been made with "carrier" and "intermediate" varieties. A cropping trial has been planted with 7 strains of Huxley, including the virus-tested clones F25 and F64 and the 5 selected commercial stocks at present being used as interim stocks in the Ministry of Agriculture's Nuclear Stocks Scheme. Royal Sovereign M40 is also planted in the trial for crop weight comparisons. With the new vaporized nicotine control for strawberry aphis it is expected that effective control of virus spread will be possible.

Another preliminary cropping trial of two virus-tested clones of Tardive de Leopold, and one of Oberschlesien has been planted ; but the present performance of some of these clones is not so good as was hoped. A number of other virus-tested clones are being brought on for cropping when required.

Collaboration with the workers at Bangor has been maintained in the growing of certain tested clones under isolated conditions.

A review on "Strawberries, making the most of a limited acreage", was published (Esf47) showing how application of research findings can produce maximum yields. Two questions newly discussed were the use of lime, and the effect of straw on frost damage.

Propagation.—At the request of the Ministry of Agriculture, supervision of the Strawberry Nuclear Stocks Scheme, involving some 16½ acres of isolated block runner beds at five different centres in Kent and elsewhere, was undertaken. Over three-quarters of a million runners of Royal Sovereign M40 were produced and distributed to the industry. The demand for runners exceeded the supply, and plans have been made for extension of the scheme in 1943, including selected stocks of the variety Huxley's Giant as well as larger areas of Sovereign.

Further extension of propagation beds of selected raspberries, loganberries, and black currants has been made.

Breeding.—As mentioned above, many *raspberry* seedlings are showing great promise of superiority to varieties now in commerce.

Comparative cropping tests of new seedling *black currants* raised at the Station are continuing. Several of the seedlings have cropped more heavily than the established varieties with which they were compared.

In a search for more vigorous disease-free *strawberries*, extensive crosses were made between a number of the more promising seedlings from crosses between *F. chiloensis*, *F. virginiana* and Royal Sovereign.

Cultural Measures.—Several strawberry cultural trials were concluded, and will be reported on shortly. The latest trial of burning the straw litter after fruiting, once more showed a heavier crop on those plots where burning was done.

Irrigation.—Further irrigation trials with strawberries and raspberries, once again gave favourable results. There seems little doubt that useful crop increases in soft fruits—and also in vegetables—can be obtained in England by watering, and more experiments on the most economic time and amount of irrigation should be well worth while.

C.—Nuts.—Observations on the time of leafing-out and flowering, which are important in relation to spring frosts, have been continued on selected *walnut* varieties, now planted in permanent positions.

D.—Horticultural Meteorology.—Routine meteorological observations were maintained. These data continue to be of great importance in almost every research project. Among other striking phenomena, some exceptionally hot and some very moist days were recorded at the end of August. Shortly afterwards, severe skin scald was found on wall peaches (Peregrine) and certain varieties of apple. A brief descriptive note was published, showing that in the apple the varieties most affected were Newton Wonder, Bramley's Seedling and Allington Pippin. (See page 50.)

Publications during the Year

In Relation to Tree Fruits.

Studies in Framework Grafting of Mature Fruit Trees. II. Apples. R. J. Hilton. J. Pomol., 1942, **19**, 149-67. (Eg22.)

The advantages of the quick reworking of mature fruit trees are discussed and its adoption in various countries is summarized. The four main methods of framework grafting, two cleft and two bark, are described. An account is given of exact experiments with apples (Worcester Pearmain worked on Gladstone frames) comparing time of grafting and length of scion suitable for the above methods. There was no significant difference in percentage take between any of the methods.

Cleft grafting.—Operations were carried out from February to June. At the start the *earlier* grafted trees made the most growth and in these, long grafts (eight buds) gave more growth than short ones (four buds). The growth of the stub grafts was strikingly more vigorous than that of the side grafts throughout. After three seasons there was a general tendency for growth to even up. The trees grafted in May developed more fruit buds in the first season than all the others, and though in the second year they produced slightly fewer, a higher proportion set fruit. In this and in the third season these trees were outstanding in their crops. The blossoming and crops of the remainder were alike. Long scions resulted in heavier crops than short ones. Within the first three seasons the actual crops per tree ranged from one to three bushels.

Bark grafting.—It was possible to make bark grafts only from April to June. Whilst in general the results with regard to vigour and blossoming confirmed those of the cleft grafts the differences were not so striking, and as a whole bark grafts were, at the start, much less vigorous than cleft grafts. Of the two types, the growth from inverted L grafts was more vigorous than that from awl grafts. Whilst the cropping of April and June bark grafts was very similar to that of comparable cleft grafts, that of the May bark grafts was not outstanding.

Methods of cleft and bark grafting were intermixed on the same tree and, apart from differences in vigour of growth due to the different types of graft already observed, there was little evidence of any interaction one with another. In direct comparisons on the same tree, stub grafting resulted in more growth and more fruit buds than budding, which, in its turn, was superior to inverted L grafting. An examination of the effect on growth of the position of the scion on the frame indicated that this was indeterminate in the season after grafting, but that apical dominance was likely to become re-established eventually. The influence of fifteen ten-year-old framework intermediates on the vigour of Cox's Orange Pippin scions was not markedly different in the first four seasons after grafting. Differences in fruit bud formation and cropping were more noticeable.

Studies in Framework Grafting of Mature Fruit Trees. III. Plums. R. J. Hilton and T. N. Hoblyn. J. Pomol., 1942, **19**, 168-85. (Eg23.)

Two experiments designed to explore the possibilities of frameworking mature plum trees are described. In the first, cleft and bark-grafting methods were compared, seven scion varieties being grafted on 14-year-old Czar trees. Cleft methods, stub and side grafts being equally good, proved superior to bark grafts (inverted L and awl) in take. They lost, however, a rather higher percentage of scions from Silver Leaf, though this was probably a mischance, a few badly affected trees being found to have rather larger wounds, made in preparing the trees for grafting, than the others. Severe damage to scions in the first season from a summer gale indicated the need for some form of summer pruning, especially for vigorous varieties. There were large differences in the growth and cropping of the seven scion varieties, but these were complicated by a big variation in take; for this, the condition of the scion wood was of great importance.

In the second experiment, the intercompatibility of twenty-three scion varieties, including high quality and late maturing sorts, and three intermediates, was tested. Six to eight varieties were cleft

grafted on individual scaffold branches of each tree. The factors mentioned above again complicated the results, differences in susceptibility of the intermediates to Silver Leaf being clearly shown. However, up to three years after grafting, there was no clear evidence that any of the sixty-nine combinations tried were incompatible, despite the fact that one of the intermediates and some of the scion varieties were known not to be compatible when worked on certain rootstocks.

Studies in Framework Grafting of Mature Fruit Trees. IV. A comparison of frameworked and topworked Apple Trees. R. J. GARNER. J. Pomol., 1942, **19**, 186-96. (Eg24.)

An experiment is described in the reworking of 13-year-old Newton Wonder apple trees—a variety particularly susceptible to Silver Leaf disease—with scions of Laxton's Superb. A direct comparison was made of three topworking methods and one of frameworking. The methods of topworking used were oblique cleft grafting, rind grafting, and a further one in which the trees were rind grafted, but two whole branches of the original tree (sap-drawers) were retained for a season to facilitate recovery. On the frameworked trees stub grafting was used throughout.

Rind grafted trees (no complete branches retained) were most seriously affected by breakage and disease, made least growth (as shown in new shoot and trunk growth), and cropped less heavily than trees worked by the other methods. The retention of branches on rind grafted trees reduced loss by breakage and disease, encouraged scion growth and trunk thickening, but did not cause the trees to crop significantly more heavily than those rind grafted. Oblique cleft grafted trees lost fewer scions by breakage and disease, made more new scion growth and cropped rather more heavily than rind grafted trees.

Frameworked trees lost no scions by breakage and suffered less from disease than any of the topworked trees. New scion growth was considerably greater than in the rind grafted trees and slightly greater than in the oblique cleft grafted ones. Frameworked trees cropped heavily in the third season and continued to bear more fruit in subsequent years than trees worked by any of the other methods. The first fruits borne on frameworked trees were shown to be of better quality than those from topworked trees.

Grafting Established Fruit Trees. A wartime solution to a wartime problem. R. J. GARNER. Rep. E. Malling Res. Sta. for 1941 (1942), 60-68. (Eg25.)

In Relation to Small Fruits.

Raspberry Planting: Some Notes on Varieties. N. H. GRUBB. Rep. E. Malling. Res. Sta. for 1941 (1942). 52-3. (Esf45.)

How to Improve Black Currant Plantations. J. AMOS, R. G. HATTON and T. N. HOBLYN. Rep. E. Malling Res. Sta. for 1941 (1942), 53-6. (Esf46.)

Strawberries: Making the most of a limited acreage. W. S. ROGERS. Rep. E. Malling Res. Sta. for 1941 (1942), 56-60. (Esf47.)

Horticultural Meteorology.

Low Temperature Injury to Fruit Blossom. II. A Comparison of the Relative Susceptibility and Effects of Experimental Factors on Three Commercial Apple Varieties. C. P. FIELD. Rep. E. Malling Res. Sta. for 1941 (1942), 29-35. (E188.)

Winter Injury to Fruit Trees by Frost in England 1939-40. I. MODLIBOWSKA and C. P. FIELD. J. Pomol., 1942, **19**, 197-207. (H41.)

Observations on the nature and extent of injury to fruit trees at East Malling during the severe winter of 1939-40 are recorded and the results of the remedial measures tried are described.

Older trees suffered less than younger ones. No trees or branches were killed outright; but cracking and lifting of the bark of the trunk, and sometimes of the crotch and branches, occurred in five varieties of apple, one of pear, and one of damson. One-year-old wood, fruit- and wood-buds of pears were injured. The outer rind of loganberries suffered, and canes of older plants were killed. Unearthed quince stool beds were badly damaged. Damage was greatest in the lowest-lying parts of the plantations, and most frequent on the sides of the trunks exposed to the S. and S.W. Apple trees which had a double dressing of potash suffered more than those with a single dressing. On the dwarfing rootstock Malling IX least damage occurred; on the most vigorous ones it was considerable, but it was worst on the rootstocks of medium vigour.

Fastening down the loosened bark with small nails inserted in two rows on each side of the longitudinal cracks in the bark and sealing the cracks with vaseline proved a useful remedial measure, for healing was more rapid and satisfactory in nailed than in unnailed trees. The uplifted bark carried the cambium with it; callus formed on the inner surface of the bark and eventually new phloem and xylem were produced here. No callus formed on the wood. In bark raised mechanically from healthy trees in April, when sap-flow had already started, cleavage took place in the cambium itself,

part of it remaining attached to the wood and the other part to the bark ; callus was produced from both portions.

In no instance was the winter injury so severe as to affect the subsequent development of foliage, growth or fruiting of the trees, which remained apparently normal up to October, 1941.

Notes on the Winter Injury to Fruit Trees in England. 1939-40. C. E. Cornford and N. B. Bagenal. J. Pomol., 1942, **19**, 208-11. (H42.)

In the first part of the paper notes are given on the results of a survey carried out on 25 Kentish fruit farms in August, 1940, of damage to fruit trees resulting from the severe frosts in January, 1940. The damage was found to vary according to altitude, age of tree, variety and kind of fruit. Apple trees suffered more severely than other fruits.

In the second part of the paper notes are given on the results of a questionnaire sent out in April, 1940, to 14 fruitgrowers in different parts of England on the damage from splitting and lifting of the bark of apple trees as a result of the severe frosts of January 1940. The answers showed a wide range of varieties to be affected and a varying degree of damage including some cases of serious permanent damage.

Weather Conditions during 1941. H. C. Chapelow and H. M. Tydeman. Rep. E. Malling Res. Sta. for 1941 (1942), 35-8. (H43.)

Miscellaneous.

The Experimental Farm. Section I. J. Amos, F. H. Beard, R. G. Hatton, T. N. Hoblyn, and H. B. S. Montgomery. Rep. E. Malling Res. Sta. for 1941 (1942), 11-13. (E186.)

General Review of Research Work, with Lists of Papers published during the year. Section II. Rep. E. Malling Res. Sta. for 1941 (1942), 14-28. (E187.)

War-time Fruit Surveys and the Future of Fruit Planting. R. G. Hatton. Report on Papers and Discussion at Horticultural Education Association Conference, October 1941. H.E.A. Occasional Publication No. 3, 1942, 51-3 and 56. (E189.)

Manuring of Fruit and Vegetables in War-Time. Water Supply, and Supply of Organic Matter. W. S. Rogers. Report of Papers and Discussions at Horticultural Education Association Conference, October 1941. H.E.A. Occasional Publication, No. 3, 1942, 49-50. (P6.)

Plants and Their Water Supply. W. S. Rogers. The Listener, 1942, XXVIII, 704, 53.* (P7.)

II. STATISTICS AND RECORDS

By T. N. HOBLYN

Records.—During 1942 a census was made of all the fruit trees planted on the Station. Including cordons and new seedling fruits, there were in July some 24,000 trees, of which rather over half were apples. This gives some idea of the immensity of the task of recording and the bulk of records to be filed and summarized ; for, every year, at least one record is made on practically every one of these trees, whether it be of growth, crop, fruit quality or disease.

Sampling.—In 1942, some 5,000 apple trees had crops ranging from 1 to 17 bushels per tree, while many more carried smaller, but none the less experimentally important crops. With wartime reductions in recording labour and increasing crops, the older methods of counting the fruits and weighing every box have had inevitably to be modified, the frequent handling of the boxes alone rendering them impossible. It has now been established that, while the weight of a full box varies from one variety to another, by taking quite a few sample weights, the crop weight can be estimated with very fair accuracy by counting the number of boxes for each tree. Advances were made this season also in the technique of sampling for the estimation of fruit size, economy in time and labour and a minimum of error being aimed at. There are indications, however, that the methods may have to be modified according to variety.

Variation Studies.—An investigation has been started into the nature and causes of variation in the amount and intensity of apple scab. An examination has been made of the statistical distribution of the occurrence of scab on the fruits and the intensity of infection ; and this has indicated possible improvements in sampling and recording methods, which will give a more reliable scale for measuring the infection and simplify the subsequent statistical analysis of the data. (See VII. Insecticides and Fungicides.)

Experimental Design.—Plans have been prepared for trials of two series of new apple rootstocks (see I. Pomology). The rootstocks selected are the survivors of rigorous selection in previous nursery trials and something is already known of their potentialities for vigour. The experiment is being

* Reprinted on page 103.

made, therefore, of segregating the trees on the rootstocks in each series in three sub-groups according to their probable vigour. The trees in each group will be planted at their appropriate distances and their cultural and pruning treatments may vary from group to group. As a check on the method, standard rootstocks will be selected and included in each of two adjoining groups. This marks an advance in the design of trials of new rootstocks, which will become of increasing value as the technique for forecasting the potentialities of a rootstock from its root anatomy is perfected.

The Section collaborated with members of the staff of the Imperial College in designing trials of vernalized cereal and herbage crops, and thus was enabled to widen its experience with annual crops.

III. PLANT PHYSIOLOGY

By M. C. VYVYAN

Vegetative Propagation (in collaboration with Pomology Section).—*Layers.*—A report (E185) has been published on rooting in layer beds of a shy-rooting plum rootstock.

Hardwood Cuttings.—An experiment with cuttings of a plum rootstock was carried out in 1941-2. Cuttings from the base of a shoot rooted better than those from the middle. Treatment with a growth substance and a dormancy breaker, used either separately or in conjunction, proved harmful at the concentrations used. Cuttings planted immediately after treatment did better than those forced for some weeks in a hot house. The percentage that rooted was not markedly greater in those planted in the bed of a drained lake than in normal loam, but the individual plants were larger. The mean weight and its distribution between roots, trunk and branches have been determined for cuttings from a drained lake and from normal loam. The results are being examined.

Attempts at finding quick laboratory methods for determining the rooting powers of cuttings of different varieties, and the response to various treatments are in progress, but so far have not given promising results.

A report on experiments with hardwood cuttings appears on page 40.

Spraying to reduce pre-harvest drop of fruit.—A note on the results of an experiment carried out on Miller's Seedling apple trees in 1941, has been published (F36). Sprays containing alpha naphthalene acetic acid, at concentrations of 5 or 10 parts per million, were applied three weeks before the time of picking. At the time of spraying the trees on an average carried $3\frac{1}{4}$ bushels of fruit. By the time of picking, the unsprayed trees had lost about a bushel each through drops, whilst the sprayed trees had only lost about half a bushel each. There was thus a saving of about half a bushel per tree. The cost of spraying including labour, would be less than £2 per acre. The application of the spray would thus be well worth while. Dr. Haddow, of the Chester Beattie Institute, has collaborated by testing the substance for possible harmful effects and has reported that " no carcinogenic or other harmful effect has been obtained in experiments . . . carried out for more than a year." The spray can therefore be recommended as reasonably safe.

In 1942 the spray was tried on Conference pears with very marked and significant results. The loss through drops was reduced from over 20 per cent. to less than 5 per cent. The spray acted only on the good fruit, diseased fruit fell as freely from the sprayed as from the unsprayed and represented most of the " drop " from the sprayed trees. In an experiment on Bramley's Seedling apple, carried out in 1942, alpha naphthalene acetic acid was compared with its acetamide ; preliminary inspection of the data suggests that the two substances have much the same effect. (See also page 47.)

Diagnosis of mineral deficiencies (in collaboration with Biochemistry). The first set of samples taken in 1941 to determine which morphological type of apple leaf could be best used for analytical diagnosis of deficiencies was analysed. Further sets of samples were taken in 1942, including one series to determine the effect of leaf scorch on mineral content.

Investigations of the conditions governing response to diagnostic plant injection were begun. (See IV. Biochemistry.)

PUBLICATIONS DURING THE YEAR

Further Note on the Reduction of Pre-harvest Drop in Apples by Use of Dilute sprays of Alpha-Naphthalene Acetic Acid. M. C. VYVYAN. Rep. E. Malling Res. Sta. for 1941 (1942), 38-40. (F36.)

Studies on the Vegetative Propagation of Plum rootstocks by Layering. A. C. SINHA. J. Pomol., **20**, 1-11, 1942. (E185.)

Censuses of rooting and of shoot growth in Pershore plum layer beds carried out during the autumn of 1932, 1938 and 1939, showed that :

Rooting varied from year to year, and there was some indication that it was influenced by the rainfall during the critical period for growth. The number of layers per plant had no significant

influence on the rooting of the shoots. Short layers had proportionately more shoots than long ones, and the percentage rooting progressively decreased with increasing length of layer. The number of shoots and the percentage of them that rooted were significantly greater when they were situated near the base of the parent plant than when farther away. The diameter of the shoots showed a tendency to decrease with increasing distance from the parent plant. Percentage rooting increased with increasing shoot diameter up to a certain point ; beyond this no clear conclusions could be drawn. Shoots nearer the base of the parent plant were longer than those farther away. No correlation was found between length of shoot and rooting performance. The longer the etiolated portion of the shoot, the larger the number of roots. Shoots arising from buds on the under-surface and the sides of the layers rooted better than those from buds on the upper-surface. Shoots that continued terminal growth until late into the season rooted significantly better than those which ceased growth earlier.

Experiments carried out on the layer beds to improve rooting showed that it could be significantly increased, without reduction in the number of shoots, by :

(*a*) Cutting back the layers to about 2 feet.

(*b*) Partial disbudding of the shoots at the time of layering.

Application of lanolin paste containing indole-butyric acid in various concentrations did not affect rooting in Pershore plum or Pear C8 layers ; but rooting in Myrobolan B was improved by summer application to the shoots. Most of the roots appeared at the point of application, where a large callus developed.

IV. BIOCHEMISTRY

By W. A. ROACH and B. D. BOLAS

During 1942, Dr. B. D. Bolas and Dr. D. W. Goodall of the Research Institute of Plant Physiology, have continued to co-operate with this Section. The Agricultural Research Council has augmented this joint team and has enabled it to extend the application of plant analysis and plant injection for the detection of mineral deficiencies to potatoes, cereals and other crops of particular importance to the country during the war. Preliminary reports on these special activities have been made to the Agricultural Research Council.

Some of the pre-war programme has also been continued.

A method has been developed for cereals and given preliminary trial for use in the field.

A leaf injection method has been worked out for the tomato and a number of responses have been obtained in commercial greenhouses. The selection of the best type of leaf for injection requires more study. Further data have been accumulated on the best time to look for response to injection, e.g. apple in 14 days, potato 7-10 days, tomato 14-21 days.

Attempts have been made to reduce to a minimum the travelling connected with diagnosis by leaf injection. After a visit to make the injection, a second visit for the diagnosis has been saved by having the shoots sent to the Research Station. In one case, no visit was paid ; injections were carried out on shoots sent to East Malling and kept alive in a moist atmosphere with their cut ends under water. A definite response was obtained. This method seems worth further trial for fruit trees.

Plant Analysis Methods.—Evidence has been obtained for the following sources of error in the photographic part of the *flame* method of spectrographic analysis ; background on plate due to the glow of the burning material, due to the flame itself and due to the emulsion or development conditions ; departure of the emulsions from the Bunsen Roscoe law ; failure of stimuli to summate ; variable threshold values ; variations in gamma values of the emulsion within plates, between plates and for different wave-lengths ; change in characteristics of the sensitive material and the latent image with time. Efforts are being made to reduce such errors to a minimum.

Progress has been made with the *spark* method of spectrography. This will be facilitated by a new spectrograph made available by the Agricultural Research Council.

Work has continued on the *polarograph*. The old model of the instrument was found unsatisfactory, and work has started on a new instrument provided by the Agricultural Research Council.

Spectrographic Analysis of Apple Leaves.—Dr. D. W. Goodall has continued his spectrographic work on leaf samples from the manurial trials on the Research Station (Plot C2) to determine which types of leaf most readily show mineral deficiencies.

Leaves gathered in September, 1940, from primary vegetative spurs (especially the older leaves) contained more calcium, magnesium, iron and manganese than those of the leaders or the secondary spurs from fruiting spurs. The content of all these elements fell regularly from the basal to the apical leaves of the primary vegetative spurs, but that of the leaves of the secondary spurs was uniform. In the leaders the trends varied according to the element. Potassium, on the other hand, occurred in greatest amount in the leaders, especially in the younger leaves. Differences in manganese content

between different plots were greatest in the basal leaves of vegetative spurs. Differences in potassium content were similar in the two types of spurs, but less marked in the leaders, especially in the basal leaves. There were no similar significant differences in the content of other elements.

The difference between the potassium content of leaves gathered in May, 1941, from plots receiving single and double dressings of potash was larger in leaves from fruiting than in those from vegetative spurs, but this difference did not quite reach significance.

Work has been started to determine whether minerals migrate from leaves with scorch or other symptoms as in senescence, and if so to what extent this will interfere with the use of such leaves for diagnosing mineral deficiency from analysis.

No fresh work has been done directly on the rootstock problem but results have been obtained having a bearing on it. Thus, in the above-named work, all types of leaves from trees on rootstock Malling XII (vigorous) were richer in potassium than corresponding ones from trees on Malling IX (dwarfing). On M.XII the leaves of fruiting spurs contained more potassium than those of vegetative spurs, but on M.IX there was no significant difference.

Spectrographic diagnosis has been carried out on all the material mentioned on which diagnostic injection was done, and on samples sent from many parts of the country.

In co-operation with the Pomology Section, analyses have been done on trees growing over various cover crops to determine how far differences in trees performance are explicable in terms of mineral uptake.

V. PLANT PATHOLOGY

By R. V. HARRIS

A.—Diseases of Tree Fruits.—*Bacteriosis of Plum and Cherry Trees.*—No further information was gained on the trial of Victoria plum trees with resistant stempieces, owing to the small number of cankers developing during 1942. The results of this trial to date have been summarized for publication. (See page 53.)

The collaboration with Professor Harington of University College Hospital Medical School, London, on the causes of varietal and seasonal resistance to this disease came to an end in September, 1942. During this year, bark extracts, prepared by Professor Harington and Mrs. Pitt-Rivers, were tested against *Pseudomonas mors-prunorum* in culture by Mrs. D. Oxford without showing any differential effect correlated with origin from resistant or susceptible plum varieties. She also showed that the organism could utilize a very wide range of food materials and it therefore appeared unlikely that resistance could be due to a shortage of essential food materials. Sections of diseased tissues, prepared by Mrs. Oxford, showed that the organism invaded bark tissue intercellularly and only entered cells when they had collapsed. These findings led to tests to show whether the organism develops a substance specifically toxic to the bark of susceptible trees, and this work is being continued in collaboration with Mrs. Oxford, by arrangement with the Agricultural Research Council.

Experiments in the control of bacteriosis by spraying are reported under Section VII, p. 20.

A description of Bacterial Canker of Peach was published (C179) ; the causal organism is shown to be *Pseudomonas mors-prunorum.*

Blossom Blight of Pear Trees.—In 1942, in contrast to 1941, Blossom Blight of pears was slight, which again suggests that weather conditions play a large part in determining the intensity of this disease, since abnormally cold, wet weather about the blossoming period, as experienced in 1941, did not occur in 1942. Blossom Blight in 1942 was found to be associated with the punctures caused by the Apple Blossom Weevil.

A trial of spraying and pruning as a control method for this disease was begun in 1941 and carried out in 1942, but owing to the small amount of infection yielded no results.

Wilting of Plum Shoots in Layer Rows.—Further inoculation experiments carried out in 1942 confirmed the results of 1941, showing that the disease is caused by a species of Cylindrocladium.

Brown Rot.—A paper was published (C178) showing that one cause of "die-back" in apricot trees is infection of twigs and branches by the Brown Rot fungus *Monilia cinerea.* Infection by this fungus results in blossom wilt, twig blight, and fruit rot. Measures for the control of these diseases are suggested.

B.—Diseases of Soft Fruits.— *Virus Diseases of Raspberry.*—Four new seedlings, and an unknown variety from Northern Ireland, have been tested by inarching to indicators (Baumforth's Seedling B).

The results obtained in 1940, indicating that Baumforth's Seedling B "carried an hitherto unsuspected virus", were investigated by means of a series of graft combinations.

The results of the above experiments will not be available until 1943.

Raspberry seed was collected from various sources and plants are being raised in the attempt to extend the present range of virus indicators.

An investigation of a serious outbreak of a hitherto unrecorded disease in the Norfolk Giant variety in the raspberry growing areas of Angus and Perthshire was started in 1942 in co-operation with the Plant Pathologist to the Scottish Department of Agriculture. This disease resembles in certain features the Leaf Curl (virus) disease of raspberries in North America. Experiments to determine its cause yielded no conclusive results in 1942. (See p. 48.)

Virus Disease of Strawberry.—Further samples of commercial varieties were tested by inarching to *Fragaria vesca* ; no virus-free stock of Huxley's Giant has yet been found. Samples of previously tested varieties which are now being propagated on a commercial scale were re-tested by inarching to indicators. These tests showed that roguing and other methods of field control are maintaining the original degree of freedom from virus in these stocks.

Nuclear stocks of a number of selected clones have been maintained in the glasshouse under aphis-free conditions.

A rapid deterioration (" breakdown ") of vigorous plants of the virus-resistant (" carrier ") variety Huxley's Giant (known to contain Yellow-edge and Crinkle viruses) was induced in the field by inarching them to Royal Sovereign plants also containing Yellow-edge and Crinkle viruses. This phenomenon is being further investigated.

The analysis of the virus content of infected plants by means of the aphis vector (*Capitophorus fragariae*) was begun, and was directed in the first instance to discover whether Yellow-edge and Crinkle are caused by individual viruses or by virus complexes. Results obtained showed that a virus (or viruses) inducing uniform symptoms of the Crinkle type on *Fragaria vesca* could be isolated from plants showing either Yellow-edge, severe Crinkle or mild Crinkle symptoms. The relation of this virus (or viruses) to the diseases in question has yet to be determined.

Attempts to identify component viruses of Yellow-edge infected plants by serological means and by mechanical inoculation were made in collaboration with Rothamsted Experiment Station, so far with negative results.

Strawberry Leaf Blotch.—Another paper describing this disease and the fungus associated with it was published (C182).

Loganberry Cane Spot. (See VII. Insecticides and Fungicides.)

C.—Diseases of Hops.—(See VIII. Hops.)

D.—Miscellaneous Investigations.—*Grey Mould.*—Papers were published describing the occurrence of Grey Mould *Botrytis cinerea*, on a number of weeds which may serve as sources of infection for cultivated crops (C173 and 183).

Black Rot of Carrots.—This disease, caused by *Alternaria radicina*, was recorded for Britain, and an account published (C176).

Publications during the Year

Grey Mould : A Menace to Beans. H. Wormald. Farmer & Stockbreeder, 1942, **56**, 111. (C173.)

The occurrence of *Botrytis cinerea*, the common Grey Mould, on a number of weeds, is mentioned as a possible menace to cultivated crops, with special reference to Field Beans.

Studies in Strawberry Virus Diseases. IV. Symptom Expression of Yellow-Edge in the variety Royal Sovereign. M. E. King and R. V. Harris. J. Pomol., 1942, **19**, 212-26. (C174.)

The early observations on the incidence of the Yellow-edge disease of strawberries in the East Malling selections of the Royal Sovereign strawberry are reviewed. The symptom expression of Yellow-edge is closely correlated with the interaction of temperature and soil moisture. Three phases may be recognized : (1) In early spring soil moisture is adequate but temperature during this phase is not high enough for symptom expression. (2) An intermediate phase begins when the minimum air temperature is about 60° F. ; during this period soil moisture is often too low for symptoms to become evident, and this accounts for the occasional and merely temporary appearance of symptoms during May and June. (3) The final phase supervenes as the temperature falls in late summer and autumn, and, although the soil may be saturated with moisture, the symptoms gradually fade away as the weather becomes colder.

Experiments have shown that there is no simple nutritional explanation for the differences in the intensity of Yellow-edge symptoms shown by affected plants. In a field experiment the results suggested that a mixture of strains of the Yellow-edge virus might be present but that no resistance was shown by mildly affected plants towards infection with more virulent strains.

The first result of Yellow-edge infection is a flattening of the plants, followed later by reduction in size. The flattening and dwarfing increase as the intensity of symptoms increases. Plants affected with Yellow-edge show considerably reduced runner production. Symptoms begin to be evident a week to a fortnight after environmental conditions are such that the air temperature is above 60° F. and soil moisture supply is plentiful. Such periods, when the symptoms can most easily be detected, and when roguing is possible and should be carried out, usually occur in June and, especially, in early autumn (September and October).

Studies in Strawberry Virus Diseases. V. The use of Fragaria vesca L. as an indicator of Yellow-edge and Crinkle. R. V. Harris and M. E. King. J. Pomol., 1942, **19**, 227-42. (C175).

A method is described of grafting strawberry plants by inarching stolons with stolons or with leaf petioles. This method was used to determine the virus content of selected stocks of a number of varieties of strawberries by inarching plants of those stocks to healthy indicator plants.

Of several possible indicator plants tried the most satisfactory was the common wild strawberry *Fragaria vesca* L. Certain selections of the susceptible varieties Royal Sovereign, Sir Joseph Paxton and King George were found to induce no visible reaction in *F. vesca*, and were thus considered to be virus-free.

Selections of certain varieties that showed no symptoms of disease themselves transmitted disease when grafted to *Fragaria vesca* in which symptoms became evident. Nearly all the selections of such carrier varieties induced symptoms in *F. vesca* and were, therefore, not virus-free, but one strain of Huxley's Giant appeared to be quite free from viruses and is being propagated for further trials.

Observations and experiments on possible seed transmission of strawberry viruses yielded negative results.

Black Rot of Carrots. H. Wormald. Gdnrs Chron., 1942, **111**, 172. (C176.)

Black Rot of carrots, caused by *Alternaria radicina*, is recorded for Britain.

A Stalk-end Rot of Apples. H. Wormald. Gdnrs Chron., 1942, **111**, 220. (C177.)

Apples with a stalk-end rot were found to be attacked by fungi, some by *Botrytis cinerea*, others by one or the other of two species of Phoma.

The Brown Rot Diseases of the Apricot. H. Denham and H. Wormald. J. R.H.S., 1942, **67**, 261-3. (C178.)

One cause of " die-back " in Apricot trees is infection of twigs and branches by the Brown Rot fungus *Monilia cinerea* (*Sclerotinia laxa*). Infection by this fungus results in blossom wilt, twig blight, and fruit rot. Measures for the control of these diseases are suggested.

Bacterial Diseases of Stone-Fruit Trees in Britain. VIII. Bacterial Canker of Peach. H. Wormald. Trans. Brit. mycol. Soc., 1942, **25**, 246-9. (C179.)

A bacterial canker of a peach tree is described. The organism isolated from the canker, when inoculated into peach, plum and cherry branches, produced typical bacterial cankers. The organism in its chief characters conforms to *Pseudomonas mors-prunorum* Worm. and is therefore referred to that species.

Notes on plant diseases in 1941. H. Wormald. Rep. E. Malling Res. Sta. for 1941 (1942), 40-2. (C180.)

Strawberry Leaf Blotch. H. Wormald and H. B. S. Montgomery. Rep. E. Malling Res. Sta. for 1941 (1942), 44. (C182).

The Grey Mould of Fruit and Hops. Weeds as possible sources of infection. H. Wormald. Rep. E. Malling Res. Sta. for 1941 (1942), 44-7. (C183.)

The occurrence in Artificial Culture of Tremelloid Outgrowths on the Pilei of Coprinus ephemerus. W. G. Keyworth, Trans. Brit. mycol. Soc., 1942, **25**, 307-10. (C187.)

In an experiment made at the Imperial College of Science and Technology in 1937 it was shown that by passing a stream of sterile air over pure cultures of *Coprinus ephemerus* they were induced to form fruit bodies bearing tremelloid outgrowths, similar unaerated cultures forming normal fruit bodies.

VI. ENTOMOLOGY

By A. M. MASSEE

A.—Tree Fruits.— *Apple Blossom Weevil.*—Biological observations showed that the overwintering weevils were on the trees for a period of seven weeks, and that egg-laying continued over fifteen days.

Two control measures were investigated.

(*a*) Repellants. Six materials were tested in field trials as possible repellants to keep the weevils away from the trees.

(*b*) Dusts. The application of derris dust under favourable weather conditions was not effective in reducing the damage to the blossom on four plots of trees.

Methods of sampling the weevil population were investigated.

Fruit Aphides.—The life-cycle of the three species of " blue bug " associated with pear have been studied.

Leaf-hoppers associated with Top and Soft Fruits.—The leaf-hoppers associated with cultivated fruits have been identified and the species found feeding on them have been noted (D164).

B.—Small Fruits.— *Vaporized Nicotine Treatment for Strawberry Aphis.*—(*a*) All the strawberry plots at the Research Station which were vaporized with nicotine in 1941 were kept under observation

and the aphis population studied. (*b*) The possibility of vaporizing aphis-infested strawberry runners before planting with nicotine has been explored, and a satisfactory method has been worked out.

Strawberry Aphis Survey.—A detailed study of the migration of the aphis was undertaken in the commercial strawberry growing districts of Hampshire, Worcestershire, Wisbech and Kent.

Regular population samples were made each month on the plots at the Research Station, and on the propagation beds under the supervision of East Malling in various parts of Kent.

Economic Vectors of Rubi Diseases.—The wingless viviparous forms of two species of aphides have been tested in a further attempt to transmit raspberry mosaic. Two species of aphides and a capsid have been used in an attempt to find the vector of "Dwarf" of certain kinds of Rubi.

The possibility of applying vaporized nicotine to raspberry canes under field conditions is being studied.

Reversion of Black Currant.—The Lygus bug associated with black currant has been tested as a possible vector of Reversion.

Control of Tarsonemid Mite.—Fumigation of strawberry runners with methyl bromide has been tested again and the phytocidal action on the plants has been noted. The effect of the fumigant on the mite and egg has also been investigated.

Economic Vectors of Strawberry Diseases.—The potato Aphis (*Macrosiphum solanifolii* Ashm.) has been tested as a possible vector of Crinkle.

The work on the Aphis Transmission of Strawberry Crinkle in Great Britain has been published (D166).

Black Currant Leaf-curling Midge.—More details of the life-cycle of this obscure pest have been worked out in the field.

Systematic Study of the Phytoptidae.—Specimens sent in by economic entomologists have been investigated.

C.—Insect Pests of Hops.—(See VIII. Hops.)

PUBLICATIONS DURING THE YEAR

Aphis Transmission of Strawberry Crinkle in Great Britain. A. M. MASSEE. J. Pomol., 1942, **20**, 42-9. (D166.)

The strawberry aphis (*Capitophorus fragariae* Theob.) is shown to be a vector of the Strawberry Crinkle virus in this country. Mild symptoms of Crinkle were induced in healthy plants of the common woodland strawberry (*Fragaria vesca* L.) by transfer and feeding of either adult or immature stages of apterous viviparous female aphides, previously fed on plants of the same species showing Crinkle symptoms of like intensity. Severe and mild symptoms of Crinkle, respectively, were induced in healthy Royal Sovereign plants by colonization with alate viviparous female aphides, previously fed on Royal Sovereign plants showing Crinkle symptoms of corresponding intensity.

Notes on some Interesting insects observed in 1941. A. M. MASSEE. Rep. E. Malling Res. Sta. for 1941 (1942), 47-51. (D167.)

A Means of Preventing Outbreaks of Certain Pests in Experimental Greenhouses. A. M. MASSEE. Rep. E. Malling Res. Sta. for 1941 (1942), 51. (D168.)

Monanthia angustata H.S. (Hem., Tingidae) in West Sussex. A. M. MASSEE. Ent. mon. Mag., 1942, **78**, 48. (D171.)

This rare lacewing bug is recorded from apple "sack-bands" in an orchard in West Sussex.

VII. INSECTICIDES AND FUNGICIDES

By H. B. S. MONTGOMERY, M. H. MOORE, H. SHAW and W. STEER

Laboratory Investigations.—Ovicides.—When tested against eggs of the Winter Moth, a petroleum oil of the type usually used in winter spraying was found to be rather more toxic in a soap emulsion than in a sulphite lye emulsion. In earlier results on eggs of *Aphis pomi* the reverse was found to be the case. The question of the toxicity of oil sprays in relation to the nature and stability of the emulsions is being re-examined.

Fungicides.—A large number of tests of dithiocarbamates, thiuram sulphides, and related organic sulphur compounds has revealed the existence of the phenomenon of inversion of toxicity. With many of these substances, a range of concentration exists within which an increase in the concentration of fungicide results in decreased toxicity. This behaviour and the difficulties of statistical treatment to which it gives rise are being further investigated. Among the evidence obtained on the relation of molecular constitution to toxic properties, two of the more outstanding features in the phenol group were the greater effectiveness of nitro derivatives in comparison with the corresponding chloro compounds, and the powerful effect of phenyl groups as compared with methyl groups. To spores

of *Venturia inaequalis* 2-nitro-1 : 3 : 5-xylenol was approximately ten times as toxic as 2-chloro-1 : 3 : 5-xylenol, and 3 : 5-diphenylphenol one thousand times as toxic as 3 : 5-dimethylphenol. Some evidence was obtained that the rate of drying of the deposit, as conditioned by the relative humidity of the laboratory, may affect the performance of a fungicide. In collaboration with the School of Pathology, Oxford, several plant extracts have been tested and among them *Crepis taraxacifolia*, *Reseda lutea*, *Lindera benzoin* and *Spiraea arunchus* showed marked fungicidal activity.

Bactericides.—A report of work done in previous years has now been published (Q29).

Field Investigations.—Insecticide Trials.—*Dual Purpose Winter Washes.* In an attempt to throw more light on the period during which a dinitrocresol-oil emulsion can satisfactorily be used on apples, a large block of Lord Derby where Capsid had proved very difficult to control was sprayed, some on 9th January (with 9·5 and 8·5 per cent.), some on 9th March, and some on 30th March (each with 8·5 and 7·0 per cent.). These concentrations were approximately equivalent to 7, 6 and 5 per cent. oil. Counts of leaf trusses in May showed such variation on unsprayed trees that differences between spray treatments could not be regarded as significant. It was clear, however, that 8·5 per cent. was at least as effective applied early as applied late. The latest application, in fact, gave unsatisfactory results. Some damage was done to the blossom buds, especially by the 9·5 per cent. on 9th January. The results do not entirely agree with those of an earlier season's experiments on oil washes, but they do suggest that the winter spraying season for these washes can be considerably extended.

Substitutes for Derris.—A small *ad hoc* trial was carried out to determine the efficacy of alternatives to derris preparations for the control of Raspberry Beetle and vegetable pests such as flea beetles, caterpillars, thrips, and aphides. Two proprietary thiocyanates and pyrethrum and nicotine were compared with derris, in some cases as dusts and in others as wet sprays. The results obtained were not clear-cut, but indicated that while the thiocyanates showed no very great promise, pyrethrum in one trial gave good results. In the event of a critical shortage of the vegetable insecticides, the thiocyanates would, perhaps, repay fuller investigation at higher concentrations, especially as no damage of significance followed their use.

Fungicide Trials.—*Apple.*—The trial begun in 1941 was continued, with the inclusion of phenyl mercury chloride, which again proved very highly fungicidal though not entirely safe. Of the inorganic sulphur sprays (tested at equivalent sulphur based on 1 per cent. lime-sulphur), colloidal sulphur alone, and lime-sulphur alone or as mixtures with commercial elementary sulphur preparations, proved to be the most effective against Scab. Tetramethylthiuram disulphide was not satisfactory, in contrast to results in 1941.

In a spraying trial on commercial lines, no difference could be detected in the control of Scab by lime-sulphur and by a wettable sulphur preparation. Each gave a high degree of control. In the trial described above, the same wettable sulphur preparation was, sulphur for sulphur, less effective than lime-sulphur.

Potato.—The trial of phenyl mercury chloride in comparison with Bordeaux mixture for the control of Blight on potatoes was continued. Again there was so little Blight on the tubers as to make comparison impossible, but it was so clearly evident that the mercurial gave little or no protection to the foliage, even at a concentration that would not be economically practicable, that it is not regarded as worth further consideration as an alternative to copper sprays for this purpose. (See p. 68.)

Spray Damage Investigations. Laboratory tests already reported showed that the amount of soluble arsenic liberated from mixtures of lime-sulphur with 0·2 per cent. of lead arsenate powder reached a maximum when the concentration of lime-sulphur was approximately 0·3 per cent. In 1942 a comparable field trial was made on Worcester Pearmain and Cox's Orange Pippin. Severe damage followed the application of 0·2 per cent. lead arsenate with 0·25 per cent. lime-sulphur, especially when used in mid-June. When 1·0 per cent. of lime-sulphur was used and when 0·1 per cent. hydrated lime was added to the weak lime-sulphur mixture, the damage was negligible. The effect of the addition of lime on the fungicidal properties of the mixture requires investigation.

Spraying Allington Pippin and Worcester Pearmain apple trees in full bloom with 1 per cent. lime-sulphur or with 0·5 per cent. colloidal sulphur, each non-poisonous to insects, proved to be beneficial against Apple Scab and did not decrease the crop.

Biology and Control of Specific Pests and Diseases.—*Apple Capsid.*—The relation between date of spraying and toxicity of dinitrocresol-petroleum oil washes has been further studied. (See above, Insecticides Trials.)

Apple Blossom Weevil.—A field trial of potential repellents was inconclusive ; the most promising material was 0·25 per cent. hexachloroethane in a benzene emulsion. (See VI. Entomology.)

Bacteriosis in Plums.—The spraying trial was continued, but infection was slight and the results inconclusive. There was no appreciable spray damage, and unsprayed control trees were defoliated first in autumn.

Apple Scab.—Infection was light in 1942, in contrast to results in 1941. Nevertheless, indications

are now forthcoming that on well-grown trees of Cox's Orange Pippin and Allington Pippin, moderate annual dressings of sulphate of ammonia applied for several years are beginning to show a cumulative effect in rendering the fruits more susceptible to Scab than those on comparable unmanured trees. Weakly trees of the same varieties were even more lightly infected, and showed no such indication.

The influence of cover crops and their treatment on the incidence of Scab in Worcester Pearmain is being studied. (See I. Pomology.)

Further data were obtained in the field trial, by spraying and by injection, of zinc sulphate as a nutrient in its possible relationship to the incidence of Scab, but infection was very light and the results were, on the whole, inconclusive, though some indication was obtained of the beneficial effect of spraying with zinc sulphate-lime " Bordeaux " on the incidence of Scab on the foliage.

Special attention is being given to methods of recording the incidence of Scab, in collaboration with the Statistics Section.

Apple Canker.— The spraying trial was continued, and some promise was shown by copper sprays. Temporary cover crops of two years' duration showed little influence on tree resistance, but some evidence was obtained of a depressing effect on Canker by grassing down Cox's Orange Pippin. (See I. Pomology.)

Loganberry Cane Spot.—Two copper sprays, one pre-blossom in May and the other post-blossom at the end of June (Beetle stage), gave fairly good control of heavy infection, compared with the first of these alone, which gave only slight control. A single spray applied in September, 1941 (after cropping) was ineffective as regards infection in 1942. Infection was greater on the leaves of 1942 fruiting cane where it had been trained beneath rather than above the fruiting cane in 1941, though this effect of training was greatly reduced where the best spray programme was given. (See V. Plant Pathology, and I. Pomology.)

PUBLICATIONS DURING THE YEAR

Fruit-growers' War-time Task. Maintaining High-Point Economic Status. M. H. MOORE. Fruit-Grower, 1942, **93,** 245-6. (Q30.)

A plea for increasing the production of home-grown fruits through the control of pests and diseases by spraying.

Sun Scald of Fruits. M. H. MOORE and W. S. ROGERS. Gard. Chron., 1942, **112,** 166-7. (C186.)

A description is given of Sun Scald symptoms on peach, apple, and tomato, first seen a few days after the occurrence of a short period of very high temperatures with many hours of sunshine at the end of August, 1942. (See also page 50.)

Laboratory Tests of Bactericides on the Plum and Cherry Bacterial Canker Organism (*Pseudomonas mors-prunorum* Wormald). 1. The Toxicity of Some Inorganic Materials, Especially Copper Compounds, and the effect of Hydrogen Ion Concentration on the Organism. H. B. S. MONTGOMERY and H. SHAW. Ann. appl. Biol., 1942, **29,** 399-403. (Q29.)

In laboratory tests of twenty-nine metals in the form of soluble salts, mostly nitrates, the most toxic to *Pseudomonas mors-prunorum* (Worm.) were mercury, silver, gold, uranium, and copper, in descending order. Differences in toxicity among the various copper compounds and preparations could not be explained by differences in the hydrogen ion concentration of the medium, but the outstanding activity of Bordeaux mixture among the insoluble forms of copper was accountable in terms of the alkalinity produced by the lime component. The range of tolerance of the organism to hydrogen ion concentration was about *p*H 3·2 to 10·4.

Notes on the Use of D.N.C. Winter Wash. H. SHAW and W. STEER. The Kent Farmers' Journal, 1942, **52,** 17. (Q32.)

A review of the characteristics and field performance of the dinitrocresol dual-purpose winter wash. Precautions necessary for effective use are outlined and prospects for development and improvement are discussed.

VIII. HOPS

A.—Varieties and Cultivation Trials.

By F. H. BEARD

Commercial Varieties.—The propagation of the clonal collection of Goldings has been continued in isolation and material is now ready for planting a cropping trial. This trial will also provide material grown under uniform conditions for controlled brewing trials and physical examination by experts. In addition propagation plots of an early and late Golding and our best strain of Fuggle will be planted to provide a source of disease-free stock.

New Varieties.— The crops from about 120 varieties were dried separately in order that the yield could be estimated and samples taken for analysis if required. Thirty-six new varieties were harvested

separately for the first time. Seven gave estimated yields of over 20 cwt. per acre and nine yields between 18 cwt. and 20 cwt. Samples of 52 varieties, the majority of which had not previously been analysed, were saved for subsequent determinations of P.V. Twenty-eight varieties were pressed in part pockets for use in brewing tests. The analysis of the 1941 crop showed that three new varieties R1/55, 401, CC77, had a P.V. similar to that of Brewer's Gold and Bullion Hop. If these varieties give satisfactory results in brewing tests they should be worthy of further trial, particularly R1/55 and 401, which have the easy picking quality of " Brewer's Favourite ", with less susceptibility to Downy Mildew.

Four new varieties have given a sufficiently good performance in the field and in brewing trials over a period of years to warrant their trial by growers, and the three mid-season varieties have been named by Professor Salmon. The varieties are as follows :

College Cluster (*N15 bis*), an early mid-season hop of high P.V. which has given an average crop of 21·5 cwt. per acre over seven seasons. It is remarkable for the very fruitful nature of the bine, which is of only moderate vigour.

Malling Midseason (*BB28*), an early-midseason variety of very good P.V. and an average yield over nine seasons of 18·9 cwt. per acre. Although it is not a very heavy cropper it is a very steady one, varying little from year to year. It " weighs well " needing on an average only 90 bushels of green hops to give a cwt. of dried hops.

Brewer's Stand-by (*H H44*), a midseason variety with a very good P.V. and an average yield of 17·7 cwt. per acre over a seven-year period.

O H44, a late hop with a good P.V. and an average yield of 22·2 cwt. per acre over eleven seasons. It is free from any American aroma and is somewhat of the " Golding Variety " type.

All the new varieties are being systematically tested for possible resistance to Verticillium Wilt and already resistance has been shown by certain of the varieties so far tested (see Section B below).

The above work has been carried out in collaboration with Professor E. S. Salmon of the S.-E. Agricultural College, Wye, who has published a report (B38).

Cultural Trials. No new permanent trials have been initiated as the recent plantings are not yet sufficiently established. The existing trials have been continued. The season again favoured the training of forward bine. Very wide spacing (9 ft. × 7 ft.), with the very vigorous variety OI47, again gave yields equal to that of the more normal spacing (6 ft. × 7 ft.). Cutting of the bine just below the breast wire at picking (necessary if picking is done by machine) caused a slight reduction in yield for the first time. The treatment started in 1939.

The results obtained from the several cultural trials over a period of years emphasizes the necessity of continuing these over a fairly long period, as responses to the treatments vary from season to season. The effects of " stopping " and number of bines per string on a vigorous variety is dealt with on p. 70 of this report.

Further new plantings made it possible to repeat the comparison between strap cuts and rooted sets when planted in their permanent positions. Results obtained were even more in favour of rooted sets than in the previous season. A report on the trials appears on p. 73.

Manurial Trials.—High nitrogen (219 lb. N per acre) continued to give superior yields to low nitrogen (73 lb. N) with the variety OI47. The difference was greatest with wide spacing. It was thought that low nitrogen manuring of a very vigorous variety might have given good crops with less bine, but results so far obtained indicate that whilst the bine growth was still vigorous, cropping was reduced.

Propagation Trials.—Several small scale preliminary trials of methods of vegetative propagation have been made and will be continued on a larger scale as material becomes available. The need for the rapid propagation of the new varieties and of disease-free stocks of existing commercial varieties makes it desirable to test new methods and to see if present methods can be improved. A nursery trial, in which strap cuts of three varieties, Brewer's Gold, Bullion Hop and Fuggle, were treated with a growth substance prior to planting, has given interesting results indicating a differential response between the former two varieties and the Fuggle. The trial is being repeated.

B.—Diseases of Hops.

By W. G. KEYWORTH

Fungal Diseases.—*Verticillium Wilt.*—On the recommendation of the Hop Sub-Committee of the Research Station, and representative growers, increased publicity was given this season to the need for the prompt notification of outbreaks of this disease and the application of control measures. A temporary worker was engaged during August and September and many newly reported and old established outbreaks were visited. Twenty-two outbreaks were newly reported during the season. Further information obtained on the spread of the disease from farm to farm indicated the part probably played in this spread by the blowing about of infected plant debris.

Resistance trials of Wye seedlings and other varieties were continued. A randomized trial of twenty-two different varieties was planted in artificially infected soil, using forty cuttings of each variety. Significant differences were noted in the number of wilted plants in each variety during the first season of growth, some being apparently free from Wilt and others, notably the commonly grown Fuggle variety, showing up to 65 per cent. of wilted plants.

The fallowing trial, to determine the effect on the disease of a $2\frac{1}{2}$-year fallowing period, was continued. In 1942 (the second year after replanting) 10 per cent. of the hops had contracted Wilt, thus indicating that the fallowing period had not greatly reduced the infectivity of the soil.

Tests of soil disinfectants were continued in large scale field trials. Naphthalene applied at rates of $\frac{1}{2}$ ton and 1 ton per acre did not affect disease incidence.

Other Soil-borne Fungal Diseases.—Two new outbreaks of *Armillaria mellea* disease were noted. A disease new to Britain was seen on three farms. Isolation and inoculation experiments have shown the causal organism to be probably a species of *Phytophthora* and the disease resembles the Black Root Rot disease reported from New Zealand. (See p. 62.)

Virus Diseases.—Attempts to extract the viruses from hop plants infected with Nettlehead and Mosaic were started in collaboration with Rothamsted Experimental Station.

Nettlehead.—No disease transmission was obtained in experiments on mechanical inoculation by rubbing, stripping and cutting the bines. The manurial experiments, now in their third year, have not shown any differences in the incidence of disease in plots manured with various forms of organic and inorganic fertilizers. Further observations on symptom-masking have again shown that "roguing" should be started early in the season. Nettlehead-free Fuggles have been grown for a third year and layered as a preliminary to starting the propagation of clones.

Mosaic.—The proportion of mosaic-carrier plants in commercial Fuggle gardens.—Fuggle cuttings were collected from 53 farms in the Weald and 16 farms in Worcestershire and inarched to mosaic-susceptible Golding hops. The grafts showed that 78 of the 95 Weald Fuggles (from 32 of the 33 farms) and 52 of the 74 Worcester Fuggles (from 14 of the 16 farms) were infected with Mosaic. These results demonstrate the undesirability of planting Fuggle and Golding hops in close proximity—a fact borne out in subsequent field surveys.

Mosaic potentialities of male hops.—Male hops from five hop gardens were inarched to healthy Golding hops (susceptible to Mosaic) and to carrier hops (infected with Mosaic). Some of the males transmitted Mosaic to the susceptible Goldings and were thus shown to be carrying the disease. Others contracted Mosaic from the carrier hops and so were shown to be susceptible. Thus both Mosaic-carrier and Mosaic-susceptible male hops exist and can be selected by this method for propagation and planting among similar commercial hops.

Suspected Virus Diseases.—Experiments have been started to determine whether the disorders Fluffy Tip and Split Leaf Blotch are graft transmissible. Results are not yet apparent.

C.—Insect Pests of Hops.

By A. M. MASSEE

Economic Vectors of Hop Virus Diseases.—Study of insect and allied fauna to find vectors of Mosaic and Nettlehead. Tests made with immature and adult forms of the hop thrips (*Thrips fuscipennis* Hald.) and of the immature forms of the Hop-Damson Aphid (*Phorodon humuli* Schr.) collected from badly diseased hills of commercial hop gardens.

A paper discussing the important pests associated with the hop has been published (D170).

Hop Strig Maggot.—Further study of life-cycle and control measures in the field.

Hop Frog Hopper.—Study of life-cycle and preliminary control measures.

Publications during the Year

Twenty-fifth Report on the Trial of New Varieties of Hops. 1941. E. S. Salmon. August, 1942. (B38.)

Of the 90 New Varieties tested, one cropped at the rate of $31\frac{3}{4}$ cwt. to the acre, eight at 25 cwt. or over to the acre, and twenty-three at 20 cwt. or over. Owing to the effect of lack of rain early in the season, the yields of several varieties were lower than usual. Some varieties, however, were unaffected, and "Bullion Hop" (Q43) gave a record yield at the rate of $31\frac{3}{4}$ cwt. to the acre. This variety, tested over seven consecutive years, has averaged $25\frac{1}{2}$ cwt., while "Brewer's Gold" (C9a), tested over thirteen years, has averaged $25\frac{3}{4}$ cwt.

The number of bushels (Imperial) of green hops required to the cwt. of dried hops varied from 80 to 137. The richest sample of American hops obtainable gave a P.V. (α-resin $\times$ 10) of 71; this figure was exceeded by four of the New Varieties: OM26 with P.V.96; "Brewer's Gold", three growths with P.V.s 95, 89 and 77; HH44, P.V. 86; OB53, P.V. 77. Tables are given of the preservative values

of growths of " Brewer's Gold " and of other New Varieties produced at home and abroad. Evidence is accumulating that those New Varieties which are very rich in soft resins when grown at East Malling Research Station are even still richer when grown on deeper hop soils.

Information is given on the valuations accorded by the Hops Marketing Board to certain growths of the New Varieties. While it is satisfactory that some of the New Varieties, including " Brewer's Gold ", have for the first time been classed and valued as Goldings, and have been given £17 cwt., the top price for Goldings, it is pointed out that since there is more brewing value in some of these New Varieties than in any Golding, they should not be pegged down to prices fixed for Goldings. A fairer and more scientific method would be to establish a special class for the New Varieties (which might be called the Resin Class) and to base valuations on preservative value and the known performance in brewing trials. Such valuations have been made on some New Varieties; the brewing value of OM26 was assessed at £25 10s. cwt.

Notes are given on recent brewing trials. It is pointed out that in the Report on the recent brewing trials carried out by Mr. J. S. Ford and his colleagues (in the laboratories of Messrs. William Younger & Co. Ltd., Abbey and Holyrood Breweries, Edinburgh) a high tribute is paid to the brewing value (embracing flavour and preservative properties) of the New Varieties. It was found that the copper hop rate can be considerably reduced when these high-resined varieties are used. Evidence is also given showing that evaluation of flavour based on the physical examination of hops is likely to prove purely illusory.

Some Important Pests of the Hop. A. M. Massee. Ann. appl. Biol., 1942, **29**, 324-6. (D170.)

An account is given of the important pests associated with the cultivated hop including the Hop-Damson Aphid, Red Spider, Strig Maggot, Flea Beetle and Shy Bug. The insects tested as possible vectors of mosaic and Nettlehead are also given.

Notes on Hop Diseases in 1941. W. G. Keyworth. Rep. E. Malling Res. Sta. for 1941 (1942), 42-3. (C181.)

Verticillium Wilt of the Hop (*Humulus Lupulus*). W. G. Keyworth. Ann. appl. Biol., 1942, **29**, 346-57. (C185.)

A study of *Verticillium* wilt of the hop (caused mainly by *V. albo-atrum* but occasionally by *V. Dahliae*) indicated that disease outbreaks varied widely in severity and persistence, some fluctuating in intensity from year to year and others becoming progressively more extensive. Early observations on outbreaks of the progressive type suggested that the disease was being spread during the cultivation processes. Experiments made from 1939 to 1941 supported this view and showed that diseased leaves and bine were important agents in such spread. The disease is also spread by planting infected cuttings. The disease in hops has been found on some farms to be related to the growing of either potatoes or raspberries. Experiments on soil disinfection have been started and 2 per cent. formalin has proved promising when applied at the rate of 8 gal. per sq. yd. Experimental control measures have been formulated, consisting mainly of hygienic practices designed to remove sources of inoculum.

See also C183 under Plant Pathology.

IX. TECHNICAL SECTION

The Technical Section has continued to act as a link between the Research Worker and the fruit-grower, through the medium of advisory correspondence, bulletins, monthly contributions to the *Kent Farmers' Journal* and a short film. It has also carried on with the organization of visits of members of staff in connection with the fruit survey of the county and the fruit spraying scheme of the K.W.A.E.C. In addition, instructional courses were organized for County Officers, Ministry Inspectors and others engaged in advising growers throughout the country, in this way spreading the results of recent research to a very wide audience. A total of fourteen popular articles were published during the year one of them being also broadcast.

Section III

RESEARCH REPORTS

POMOLOGY

FIVE NEW RASPBERRY SEEDLINGS

By N. H. GRUBB

THE five raspberry seedlings here described, and a few others recently distributed by East Malling Research Station to its members, resulted from crosses made in July 1931 ; the seeds germinated in the spring of 1932. A few plants in these families bore some fruit in 1933, but it was not possible to estimate their merit until 1934. From the autumn of that year onwards many were propagated ; twelve or more have been sent out for trial. The five here described are regarded as the most promising of those most fully tested ; but at least three or four more of the same parentage have not yet given an adequate idea of their merit. Four of the five were first propagated in February 1935, the fifth, " J ", a year later.

A period of eleven years from seed germination is emphatically not enough to establish the reliability of a new variety. In the last twenty years several varieties of raspberry (not to mention other fruits) have been named and introduced by raspberry breeders which, so far as can be judged, have completely failed to live up to the expectations of their raisers, and have never been of any value to commercial growers. Experience at East Malling suggests that this is due to some form of " degeneration ", probably associated with disease, which took place after the initial trials of the variety. It is not possible to be quite certain that this will not happen with one or more of the five seedlings here described.

In spite of this possibility the prospects of their success are good. Many growers in both England and Scotland are becoming dissatisfied with the only named varieties now available for planting in very large quantities—Lloyd George and Norfolk Giant. However good these varieties may have been in the past, neither can any longer be regarded as universally successful ; the risks of failure, or of a very short profitable life, of plantings made with ordinary commercial stocks of either are almost certainly greater than they are likely to be with these seedlings.

It is very probable that no one seedling will be equally well adapted to all environments. Reports from centres where several seedlings are on trial already indicate a varied choice as first favourite. Thus, although two of the five, " E " and " L ", have been sent out much more widely than the others, it is quite possible that in some places one or more of the others will be preferable to these. One place is already known where " G " is preferred to " E ", though even there the fruit of " E " is larger.

All five seedlings have Preussen as one parent. Of " G " the other parent is Lloyd George ; of " E ", " J " and " K " it is an earlier seedling derived from Lloyd George and Pyne's Royal ; and of " L " it is Baumforth Seedling A.

Cropping.—A trial planted in the winter of 1941-42 includes all five seedlings and two others, with two named varieties for comparison—Norfolk Giant and Baumforth Seedling " B ". Since the last named produced in 1943 far less weight of fruit than any other variety in the trial, and since the other two seedlings, " F " and " H ", are less promising than the five here described, they are omitted from the following table.

TABLE I.

CROP WEIGHTS (CWT. PER ACRE) OF NORFOLK GIANT AND FIVE SEEDLINGS. (Calculated from the average crop of six 50-foot rows of each variety.)

Variety.	1942.	1943.	Av. of two years.
" L "	22·3	91·5	56·9
Norfolk Giant ..	11·0	62·8	36·9
" J "	13·8	56·6	35·2
" G "	7·0	60·0	33·5
" E "	7·9	57·6	32·7
" K "	9·2	48·8	29·0

Statistical examination shows that in both years the crop of " L " is significantly heavier than that of any other variety ; whilst that of " K " is in 1943 significantly lighter than that of any other in the table. Seedling " L " has, in fact, cropped more heavily in 1943, by about 17 cwt. per acre, than any plot, large or small, of any variety, ever previously recorded at East Malling. A short row

of a more recently selected seedling (32/41) has, however, equalled this record in 1943. This result was somewhat unexpected, since eye judgment gave no warrant for expecting such a heavy crop from any of the varieties. The reason appears to be that " L " has a longer picking season than any of the others ; in this it resembles its staminate parent, Baumforth Seedling " A ".

In ripening season, judged by the date in 1943 when half the total crop had been picked, " K " is slightly earlier than any other, followed by " J ", " G ", " E " and " L " in that order, with Norfolk Giant about nine days later than " L ".

In fruit size, measured by the weight of 50 fruits from each section at each of three pickings, " E ", as was expected, has a long lead on all the rest, followed by " L ", " G ", Norfolk Giant, " J " and " K ", in that order.

Description of Seedlings.

" E " 33/132. *Plant* very vigorous, making stout canes up to 7 feet high even in poor soil. At East Malling, and in at least two other soils, has so far produced enough canes for a good crop ; but may in some soils produce too few, like its parent Preussen.

Canes erect, or nearly so, below, more nearly horizontal above, habit resembling that of Norfolk Giant, " erect-spreading " ; glabrous. Colour becoming dark reddish purple ; lower part considerably glaucous. *Spines* dark coloured, conspicuous ; few and small except on young plants and the lower parts of canes of older plants.

Fruit very large, largest of these five, size well maintained to end of season. Shape smoothly roundish or slightly ovoid. Drupelets medium size, with no tendency to fall apart or " crumble ". Flesh firm enough for all purposes, and so far as known, in all soils. Colour moderately bright red, brighter than Norfolk Giant or Pyne's Royal, but not as bright as Lloyd George at its best ; seldom becomes seriously dark coloured when fully ripe, much less so than Lloyd George or Pyne's Royal. Usually comes off the " plug " easily, plug less swollen than in many roundish fruits. Fruits mostly easy to find, not hidden by foliage. Dessert quality good.

" G " 32/166. *Plant* even more vigorous than " E ", frequently 8 feet high ; canes fairly abundant, no reports yet received of too few.

Canes " erect-spreading ", like those of " E ", downy. Colour becoming dull dark reddish purple, little glaucous. *Spines* dark coloured, conspicuous ; small, not numerous, except on lower parts of canes.

Fruit large to very large, size fairly well maintained to end of season ; rather long conical, fairly smooth. Drupelets mostly small to medium size, no tendency to " crumble ". Flesh always, so far as known, firm enough for all purposes, except perhaps when overripe. Colour very bright, equal to Lloyd George at its best, and with much less tendency to become dark when fully ripe. " Plug " long and slender, no difficulty in plugging so far. Fruit easy to find, little hidden by foliage. Dessert quality good to very good, usually preferred to " E ".

" J " 33/54. *Plant* vigorous to very vigorous, usually 6 to 7 feet, canes believed to be always abundant.

Canes almost erect, fairly stiff ; glabrous. Becoming bright red or purplish; very little glaucous. *Spines* " tinged ", inconspicuous, few and small except on young plants and lower parts of canes of old plants.

Fruit large to very large ; may not maintain its size to end of season so well as " E " and " L " ; fairly smooth ovoid-conical or truncate-conical. Drupelets medium size to rather large, no tendency to " crumble " so far. Flesh firm enough for all purposes, and in all soils so far as known. Colour bright red, brighter than " E ", but with slightly more tendency to become dark when fully ripe. " Plug " slender, fruit does not adhere to it. Fruit very easy to find, seldom hidden by foliage. Dessert quality fair to good, sweetish.

" K " 33/115. *Plant* vigorous to very vigorous, up to 6 feet or more in poor soil ; canes always abundant so far as known.

Canes almost erect, bending slightly towards the tips, glabrous or nearly so. Colour becoming dark reddish purple, little glaucous. *Spines* " tinged ", inconspicuous ; few and small except on young plants and lower part of canes of old plants.

Fruit large, sometimes very large ; size probably not so well maintained to end of season as " E " and " L ", mostly short-conical or ovoid, fairly smooth. Drupelets sometimes rather large, but with little if any tendency to " crumble ". Flesh firm enough for all purposes, and so far as known in all soils. Colour similar to that of " E " or a little brighter ; slightly more tendency to become dark when fully ripe. " Plug " rather long, slender ; fruit does not adhere to it. Fruit little hidden by foliage. Dessert quality fair to good, occasionally rather " flat " flavoured.

" L " 34/42. *Plant* very vigorous, often up to 7 feet, rarely 8 or more ; canes always abundant so far as known.

Canes almost erect, stiff; glabrous or nearly so. Becoming bright red to reddish brown, little glaucous. *Spines* " tinged ", inconspicuous, rather long and stiff, numerous.

Fruit large to very large, size well maintained to end of season; almost round. Drupelets small to medium size, no apparent tendency to " crumble ". Flesh too soft, except for jam, at East Malling; two reports from competent observers elsewhere indicate that in certain soils it may be firm enough for any purpose. Colour light bright red, the best of these five, practically no tendency to become dark when fully ripe. " Plug " much swollen, nearly round, making the fruits unsuitable for canning even where firm enough; fruit does not adhere to it. Fruit little hidden by foliage. Dessert quality good to very good; sweetish or slightly sub-acid.

Diseases.—The limited data available at this stage is thus summarized.

Virus. Mosaic leaf-symptoms have been observed on each of the five varieties, usually very slight and inconspicuous, or a mere trace. Severe symptoms associated with considerably reduced vigour have only yet been seen in " E " and " L ", and in very few plants.

In direct virus-tests, by inarching (grafting) to an " indicator-variety ", made by Mr. R. V. Harris, Seedlings " E ", " G ", " J " and " K " have shown canes infected by, but highly tolerant of, " Mosaic 2 " virus, i.e. these seedlings have approximated in behaviour to that of virus " carriers ". Anomalous results with Seedling " L " are being further examined.

Cane Blight. Three reports have been received of serious attacks of cane blight on " E ", which must be regarded as probably the most susceptible of these five, at least in certain soils and positions. Slighter attacks have been seen in " G " and " J "; " K " and " L " seem so far more resistant.

Anthracnose (Cane Spot) and Spur Blight. No serious cases of these diseases have so far been recorded on any of the five seedlings. Since both diseases can be readily controlled by spraying, even if any of the seedlings should eventually prove rather susceptible, their usefulness would not be seriously reduced.

TABLE II.

COMPARISON OF FIVE VARIETIES.

Variety.	Canes.	Size.	Shape.	Colour and Firmness.	Flavour.	Season.
" E "	Moderate number. Very vigorous. Erect-spreading.	Very large.	Roundish.	Bright. Firm.	Good.	Mid-season.
" G "	Fairly abundant. Very vigorous. Erect-spreading.	Large to very large.	Rather long, conical.	Very bright. Firm.	Very good.	Mid-season.
" J "	Abundant. Vigorous. Erect, fairly stiff.	Large.	Ovoid-conical.	Bright. Firm.	Fair to good.	Early mid-season.
" K "	Abundant. Vigorous. Nearly erect.	Large.	Short-conical.	Bright. Firm.	Fair to good.	Early mid-season.
" L "	Abundant. Very vigorous. Erect, stiff (thorny).	Large to very large.	Round.	Brightest. Sometimes soft.	Good to very good.	Late mid-season.

Summary.—Five new varieties, bred in 1931, have been selected for certain good qualities, such as vigour and abundance of cane, and promise of good cropping. They are here described in detail.

In ripening they range from early mid-season to late mid-season. When well grown their fruit is as large as that of any named variety; in shape it varies from round to rather long conical. In colour they also vary; two are very bright, and none of them becomes very dark coloured when fully ripe. All are so far easy to plug; with one exception, their fruit is always firm enough for any purpose. The flavours range from fair to very good.

Four of the five are known to be tolerant carriers of mosaic disease. One appears rather susceptible to cane blight.

These seedlings are now being multiplied in nursery beds, for further propagation and trial in raspberry growing districts.

WEATHER CONDITIONS DURING 1942

By H. C. CHAPELOW and H. M. TYDEMAN

ALTHOUGH the totals of both rainfall and sunshine recorded during 1942 were very similar to the average values for the past twenty-six years, their distribution was in many respects rather unusual. March, May and October were exceptionally wet with almost twice the expected rainfall, while April, June and November were very dry with less than half the average. June was outstandingly dry with less than a quarter of an inch of rain. Throughout the early spring, late summer and early autumn sunshine was deficient, but both April and June had a large excess over the average.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1942.

	Temperature in Screen.					No. of Ground Frosts.	Rainfall.			Sunshine.			Soil Temperatures.		
	Mean Maximum.	Mean Minimum.	Highest.	Lowest.	Mean.		Total in inches.	Heaviest fall in a day.	26 years' average.	Total Hours.	Average per day.	26 years' average.	4 inches.	8 inches.	2 feet.
January	38	27	51	11	32	25	2.38	.77	2.48	26.7	0.9	46.9	33.7	35.1	37.7
February	35	27	44	15	31	28	1.05	.37	1.88	23.0	0.8	68.6	32.1	32.7	34.8
March ..	48	35	62	22	41	20	2.50	.65	1.58	93.7	3.0	116.2	38.7	38.8	39.5
April ..	56	41	65	33	48	6	1.43	.55	2.07	215.9	7.2	127.5	47.4	47.0	47.4
May ..	62	43	75	29	52	5	4.03	.82	1.70	192.2	6.2	195.3	54.1	52.9	53.1
June ..	70	46	85	36	58	0	0.21	.16	1.48	254.6	8.5	206.5	61.5	60.2	60.0
July ..	69	52	78	41	60	0	2.16	.53	2.22	173.0	5.6	193.4	62.7	62.1	62.6
August ..	71	53	86	42	62	0	2.72	.85	2.18	147.8	4.8	181.3	63.1	62.3	62.2
September	66	49	78	35	57	0	2.49	.75	2.04	130.5	4.4	147.8	58.5	58.6	60.5
October	60	45	71	33	52	3	3.29	.60	2.70	83.3	2.7	101.0	52.0	52.9	55.0
November	48	34	57	24	41	17	1.48	.42	3.23	61.1	2.0	53.2	40.9	42.8	46.2
December	48	38	55	23	43	11	2.51	.34	2.71	44.7	1.4	38.5	42.0	42.9	44.7
Totals						115	26.25		26.27	1446.5		1476.2			

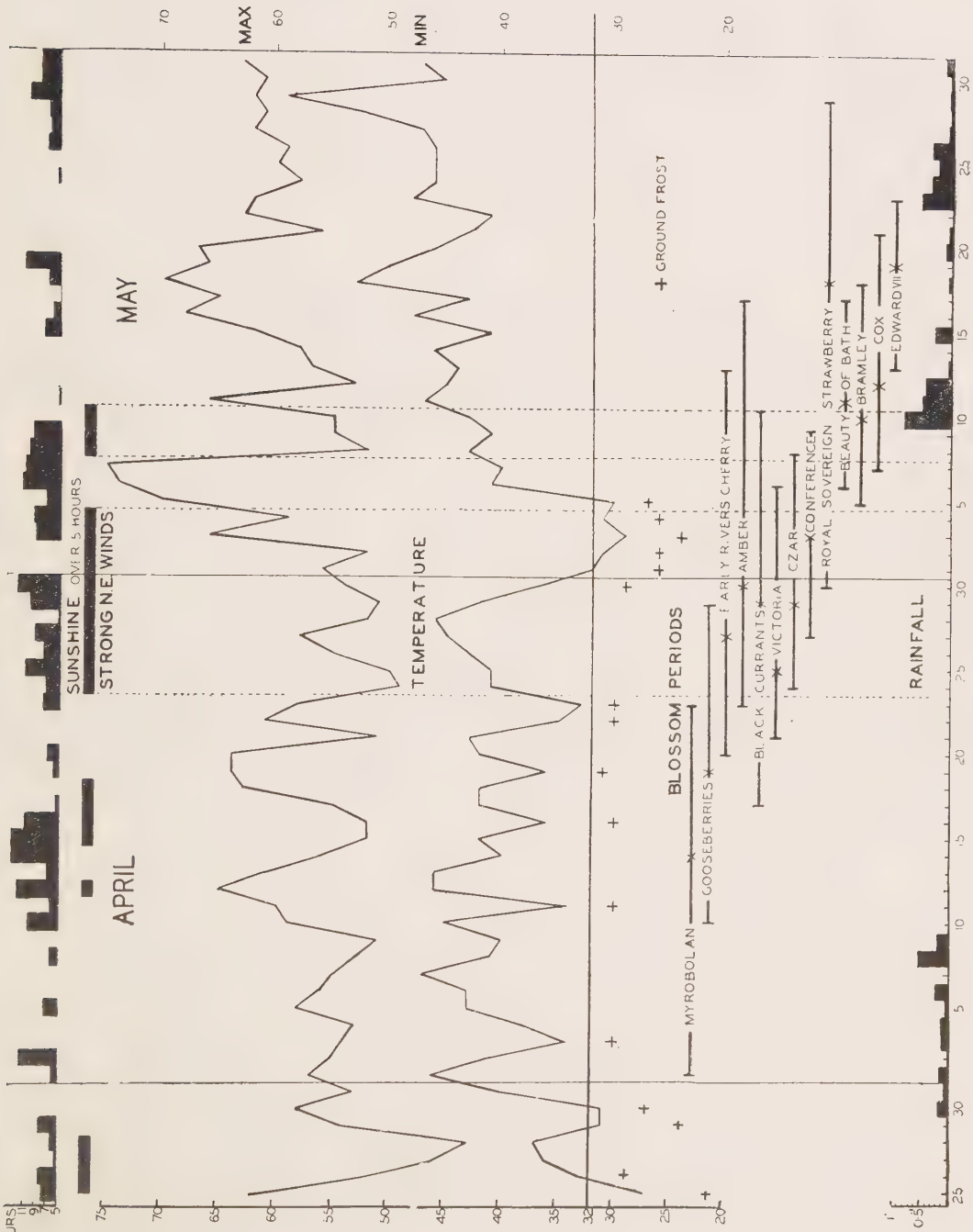

Diagram to show the Weather recorded during the Blossoming Season 1942.

From the beginning of January till the end of March temperatures ranged rather low and ground frosts occurred with unusual frequency. During the late autumn and early winter conditions were somewhat warmer than is normal, although ground frosts were prevalent during November and December.

Conditions during the blossoming of fruit varieties are illustrated in the diagram.* The most interesting period was that between the 23rd April and the 4th of May. This period coincided with the flowering of early cherries, plums and black currants. Strong N.E. winds were experienced with relatively low night temperatures and frequent slight ground frosts. Following this period the winds abated and temperatures rose considerably, making favourable conditions for pollination. Although there was a short recurrence of N.E. winds between the 7th and 11th of May, no ground frosts were recorded, and, in general, the pollination of apples, the later flowering varieties of pears, plums and strawberries was possible under almost ideal conditions.

STATISTICS AND RECORDS

AN INVESTIGATION INTO MEANS OF REDUCING THE LABOUR NEEDED FOR RECORDING CROPS

By S. C. PEARCE

Introduction.—Records relating to crop weight and quality are of first importance, and it would be particularly unfortunate if pressure of war conditions led to their serious curtailment. Even with the heavy crops of 1939 labour shortage prevented the recording of number and weight of fruit on some of the experiments where they were wanted, and the problem has become increasingly acute. This present paper describes the search for suitable sampling methods and reports the progress made by the autumn of 1942 in lightening the work of recording total crop weight and mean size of fruit for apples.

The studies are described in two parts. I. Variation between the weights of orchard boxes, and the best method of estimating the weight of a crop given the number of full boxes and the weights of some sample boxes. II. Methods of taking samples for detailed records of fruit size, including one which involves no unstacking of boxes. Suggestions are made on the sampling of other records, such as colour and disease. Such methods are, of course, called for only when the crop is large.

Material.—The material used in these investigations is given below :—

Reference.	*No. of trees.*	*Age in 1942.*	*Type and Variety.*	*Trial of*
A	61	24	Bush Bramley's Seedling	Rootstocks.
A1	16	24	Bush Bramley's Seedling	Rootstocks.
B	295	24	Bush Lane's Prince Albert	Rootstocks.
C	16	20	Half-standard Allington Pippin	Rootstocks.
D	24	29	Bush Barnack Beauty	Cover Crops.

The trees referred to as " A1 " were selected from the larger series, A, to comprise eight pairs of adjacent trees, the trees of each pair being on the same rootstock. Series C also was made up of eight pairs of adjacent and similar trees.

Records.—The contents of two bushel boxes were weighed and counted separately for each tree of series A and B. On series C six boxes, arranged in two stacks of three, were similarly recorded ; while all boxes were recorded from series D. In addition, many sets of samples were taken, which will be described later.

On all these trees the pickers were asked to make sure that the boxes were full.

I. Estimation of total weight of crop.

The obvious alternative to weighing the entire crop is to count the number of containers into which the fruit is picked, having first ascertained the weight of fruit in a container by sampling. This method is promising and has been investigated for the standard orchard bushel boxes, which hold rather more than 40 lb. of apples each. There are two disadvantages, neither very serious. First,

* The writers are indebted to Mr. T. N. Hoblyn and members of the Statistical Section who prepared and executed the diagram.

provision needs to be made for estimating the fruit in the last container if it should be incompletely filled. Estimation by eye of the proportion filled has proved erratic and actual measurement of the depth of fruit has been adopted as more reliable. Secondly, different pickers have different ideas of when a box is full.

Causes of variation in weight of a bushel of apples.—The weights of fruit in bushel boxes containing different varieties were first examined. During 1940, the contents of six boxes were weighed from each of twelve varieties. The mean weight varied from 40·5 lb. for Lord Derby to 47·1 lb. for Orleans Reinette, a difference which is significant and not unexpected. Lord Derby, a large oblong-conical apple with a wide deeply set eye, might be expected to pack loosely, besides being of light texture, while Orleans Reinette is a medium sized apple, much more compact in shape and with more solid flesh. In this trial the mean weight of the boxes of Cox's Orange Pippin was 44·7 lb. ; but six boxes of the same variety from another set of trees averaged 46·7 lb., which is significantly more. While these results may in part be due to differential filling of boxes, they suggest that the weight in a box should be estimated afresh for each trial and in each season.

It is likely that the weight of a bushel depends also on the size of fruit even within the same variety, but investigation of this point has not led yet to any clear conclusions.

Error of the suggested method.—The first method considered for the estimation of crop weight was to find a value for the weight of a bushel box for the whole plantation, and then to apply that value to each box. The errors involved in this method may be put into two classes.

First there are those sources of variation that apply to whole trees, such as the condition of fruit on a tree ; secondly, there are factors that affect only the particular box, such as a tendency to cram the last few pounds of fruit into a box already full rather than start a new one.

Variation between trees will be more serious because it will influence all boxes of a tree equally, giving a cumulative effect, while the variation between boxes within the same tree will sometimes cancel itself out. Consequently it may prove better to weigh one box from each tree and then to multiply by the number of boxes for the tree, thus avoiding the effect of variation between trees.

First, it must be found whether there is in fact much variation from one tree to another. Duplicate boxes from each of the trees of Lane's Prince Albert (B) showed that there were significant differences between trees ($P = \cdot001$), though a similar investigation on Bramley's Seedling (A) gave negative results. That such differences can arise apart from rootstock effects is shown by the results for Allington Pippin (C) on which six boxes were weighed from each tree and showed significant differences between trees of the same pair, though these were adjacent and on the same rootstock.

These duplicate box weights for Bramley's Seedling (A) and Lane's Prince Albert (B) were then used to determine the variation between boxes from the same tree and between the mean weight of all the boxes for different trees. This second variation could not, of course, be measured directly because only two boxes had actually been weighed from each tree, but it was easily estimated.

These variances* are shown in Table I, all weighings being in pounds.

TABLE I.

VARIANCE OF THE WEIGHT OF BUSHEL BOXES OF APPLES.

	Between boxes from the same tree.	Between mean box weights for different trees.
Bramley's Seedling (A) ..	5·02	1·20
Lane's Prince Albert (B) ..	3·90	1·83

From this table it will be seen that differences between mean box weights of different trees were less than those that may be found between different boxes from the same tree.

Discussion.—With these figures known it becomes possible to judge the merits of different methods of estimating the weight of the crop of a tree. It will be assumed that one sample box is, in any case, to be weighed for each tree to minimize the effect of tree to tree variation, and that such sample boxes will be sufficiently numerous to give an estimate of the weight of a bushel for the whole plantation with negligible error. Three methods have been considered : (1) Averaging all weighed boxes and multiplying the number of boxes for each tree by this average. (2) Using the actual weights for all boxes that have been weighed, and the general average for those that have not. (3) Multiplying the weight of the sample box for the tree by the number of boxes from the tree.

* The variance is the square of the standard error and is thus a measure of the extent of variation.

Using the values set out in Table I it is possible to compare the accuracy of the three methods.* Table II gives the errors that will be exceeded on the average only once in twenty times, for large and small crops using each of the three methods of estimation.

TABLE II.

ERROR WITH WHICH SMALL AND LARGE CROPS CAN BE ESTIMATED, USING THREE METHODS OF ESTIMATION AND RESULTS FROM TWO VARIETIES.

Variety.	Bramley's Seedling (A).		Lane's Prince Albert (B).	
Number of boxes per tree and approximate weight of crop.	3 (120 lb.).	10 (400 lb.).	3 (120 lb.).	10 (400 lb.).
Method of estimation 1 ..	10 lb.	26 lb.	11 lb.	30 lb.
2 ..	8 ,,	24 ,,	8 ,,	27 ,,
3 ..	11 ,,	43 ,,	10 ,,	38 ,,

For both varieties and for both large and small crops the second method has proved the most accurate, the error never being more than 7 per cent. of the total crop. It will always be more accurate than the first, and more accurate than the third also, provided that the variation from tree to tree is not so great as to make a general average inappropriate. The second method has, however, the disadvantage of being the most laborious to calculate. Of the other methods the third will prove more accurate for smaller crops, because it has the initial advantage of using the correct value for the box actually weighed; but for large crops the first will be better, provided that the variation from tree to tree is not excessive.

From the results given above it is recommended that the third method be used for crops of less than four bushels, and the first for larger ones. Where accuracy is important the second method should always be used.

When using the first method for a large plantation it is not necessary to weigh one box for each tree, provided that enough are recorded to give a reliable estimate for the whole plantation and provided that the boxes chosen are well distributed. If only ten boxes are weighed, the error is increased by between 10 and 18 per cent., while with twenty-five boxes the increase is of the order of 5 to 8 per cent. If there are only ten or twenty-five trees in the plantation and one box is taken from each, the same increases would apply for either of the first two methods.

II. Estimation of fruit size.

The mean weight of fruits is a useful measure of their size; but unfortunately it is not easy to obtain, since it is necessary to weigh the whole crop and to count all the fruits, though the recording picking bags described by Rogers (1931) are often very advantageous. A sampling method for fruit size and colour was suggested by Edgar and de Wet (1935) and Hoblyn and Edgar (1938), who took their sample from a layer in each orchard box, dividing it equally between the boxes, thus distributing it for those properties of a fruit, such as size and colour, that induce a picker to take it first or last. It was thought that this would be done even more effectively by taking vertical sections from the corners of each box, since this would give a better distribution of the sample and lessen the tendency to unconscious selection. The value of this "Modified Edgar" method is discussed below.

Error of the "Modified Edgar" method.—In 1942 two orchard boxes were selected at random from each of sixteen Bramley's Seedling trees (A1), the fruit counted and then weighed. The mean weight of an apple was ·331 lb., and the variation in size of fruit from box to box from the same tree gave a standard error of ·032 lb. Corresponding values were worked out for the whole plantation (A) and, by a coincidence, were the same. It appears, therefore, that these values were not abnormal. Then, from each of the sixteen trees two samples of 140 apples were selected by the "Modified Edgar" method, and gave a mean weight per apple of ·315 lb. with a standard error of ·0097 lb. between duplicate samples.

* The errors appropriate to these methods may be found thus. Let the variance between boxes from the same tree be U, and the variance between the true mean value for the different trees be V. Then in the first method all the boxes of a tree are subject to a common error with variance V, and an individual error with variance U. The sum will therefore have a variance, $n^2V + nU$, where n is the number of boxes for the tree. For the second method similar reasoning shows the variance to be $(n-1)^2V + (n-1)U$, while for the third method any error arises from the difference between $(n-1)$ times the weight of the sample box and the actual total weight of the remaining $(n-1)$ boxes, and the variance is therefore $n(n-1)U$. An error of more than twice the square root of the variance will be exceeded only once in 20 times.

The efficiency of the two methods may be related to the squares of the standard errors, and a simple calculation reveals that the "Modified Edgar" method of sampling is ten times as efficient as the counting and weighing of a single whole box.

This is an improvement on the result of Edgar and de Wet (1935), who worked on the same plantation, and found that a bushel sample was as good as three original bushel boxes. The improvement is so great, however, that it may be partly fortuitous.

The difference between the values for mean size of fruit given by the samples and for the whole boxes is not significant.

Time for the "Modified Edgar" method. The operation described in the last section was timed, and it was found that the time, t mins., taken to draw the double sample of 280 apples after the boxes had been laid out on the ground was related to the number of boxes, n, to be sampled, in this way.

$$t = 7{\cdot}70 + {\cdot}69\,n$$

Since this correlation is highly significant, it appears that it takes longer to draw a given size of sample from a large crop than from a small one. In addition times were taken for counting 12 bushels of Bramley's Seedling and showed that, if reasonable care is taken, apples can be counted about one a second, and that the time is not noticeably longer for large awkward fruits than for smaller ones.

The above results show that to select a sample of 140 fruits by the "Modified Edgar" method from a six bushel crop or to count three bushels would both take about six minutes, and that the sample would give more reliable information and be less trouble to weigh. Consequently the method leads to an economy of labour for a desired amount of information.

Defects of the "Modified Edgar" method. This method was tried on a large scale at East Malling in 1941, when it was found that unskilled helpers must be given a clear idea of the purpose of the rather delicate procedure or they spoil the results by carelessness or undue haste. Careful explanation and constant supervision are essential. It was soon realized that the method has another and more serious weakness, for while it saves time it does not save energy. Since it is usual for the pickers to stack the boxes before leaving the tree in order to minimize exposure of the picked fruit to the sun, the greatest expenditure of energy is incurred in unstacking the boxes, spreading them out and then stacking them again. This has to be done in sampling the boxes just as in weighing them; and when only women are employed in recording, this defect is important. Accordingly a search was made for a method that would not call for the derangement of all the stacks.

Search for an easier method. It was decided to try first a sample of one stack at random. Sixteen trees of Allington Pippin (C) were used since all of them gave crops of more than six bushels, and so provided duplicate stacks of three bushels, the pickers having been instructed to make this convenient size the standard one. Weight and number of fruit were recorded for each box in two stacks from each tree, and an analysis of variance was performed on the mean weights of fruits. It was found that the stacks within a tree differed very significantly ($P = {\cdot}001$) and that consequently it would be better to distribute the sample between all the stacks. This result probably arises from the boxes in a stack having been picked consecutively so that their fruits all come from the same part of the tree. It was decided next to try sampling from the top boxes only, since this would involve no moving at all and would distribute the sample. Before trying out this idea samples of 150 apples were taken from each fully recorded stack, fifty from the top of each box, and gave values that deviated from the known true ones with a standard error of only ·0098 lb. or 5 per cent., a result that suggested that a sample of similar size might be used in the further trial.

In the last trial twenty-four trees of Barnack Beauty (D) were used. The boxes were stacked in threes and, first of all, every box was weighed and counted separately. Then a container was weighed, and filled with 120 apples divided equally between the top boxes of complete stacks, the fruit being taken from a horizontal layer; finally the container was weighed again, this time with the sample. Incomplete stacks were ignored as balancing the first picked fruits, which also could not enter the sample. The results are set out in Table III, the trees being classified according to their crop. It will be seen that there was no bias between the samples and the true values, and that the error was reasonably small and unimportant compared with the tree to tree variation. In considering this very successful sampling it must be emphasized that the variation in size of fruit between boxes from the same tree was considerably lower than in the other varieties tried, and that with less uniform material this method might not have worked. Consequently these results, though very promising, do not completely justify the method.

Discussion. The two methods suggested are respectively an elaboration and a simplification of Edgar's method. Instead of dividing the sample into parts taken at regular intervals through the picked fruit regarding it as a single stack, the "Modified Edgar" method takes a complete section through the crop, while the simplified method takes the parts at three times the original spacing. The "Modified Edgar" method, therefore, while laborious, may safely be used however much the crop varies from box to box, and may be used for those observations on the fruit, such as the amount

and intensity of Apple Scab, which are distributed in the boxes in an unknown or erratic manner. The simplified method is even more dependent than Edgar's method on the regularity of trends through the crop, and should be used only when a previous trial has indicated its reliability for the observation to be sampled. Some evidence is presented above that it is suitable for fruit size, but

TABLE III.

THE TRUE AND SAMPLING VALUES FOR MEAN WEIGHT OF AN APPLE FOR TWENTY-FOUR TREES OF BARNACK BEAUTY CLASSIFIED BY THEIR CROP WEIGHT.

Total crop of tree :	3-5¾ bush.		6-8¾ bush.		9-11¾ bush.	
No. of top boxes :	1.		2.		3.	
	True value. lb.	Sample. lb.	True value. lb.	Sample. lb.	True value. lb.	Sample. lb.
	·329	·332	·246	·248	·210	·221
	·188	·181	·195	·189	·196	·202
	·233	·242	·156	·159	·200	·198
	·191	·187	·209	·211	·184	·188
	·168	·161	·181	·188		
	·165	·158	·189	·184		
	·168	·168	·172	·174		
	·153	·155	·188	·189		
	·132	·137	·194	·181		
	·191	·192	·146	·142		
	Standard error of samples from true values = ·0057 lb.					

for fruit colour it would be best to retain Edgar's method, either in its original form or as modified above, until more is known.

Acknowledgements.—The writer is much indebted to Mr. T. N. Hoblyn for his constant interest in this work and advice on its presentation, and to Dr. A. B. Beakbane and Miss E. M. Glenn, whose co-operation made the necessary recording possible.

Summary.—An account is given of a search for sampling methods to lighten the work of recording the total weight of an apple crop and the mean weight of single fruits.

For total weight it is recommended that one bushel box be weighed from each tree, and that computing should proceed by one of three methods, the relative merits of which are discussed. For large plantations fewer boxes may be weighed.

For size of fruit evidence is advanced to show that division of the sample equally between the tops of stacks of three bushels is adequate, provided the weighing is carefully done. Another method is discussed, which involves taking the sample as a section through the crop.

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PHYSIOLOGY

THE PROPAGATION OF FRUIT TREE STOCKS BY STEM CUTTINGS

III. FURTHER OBSERVATIONS ON HARDWOOD CUTTINGS

By M. C. VYVYAN

Introduction.—*General.*—Control of fruit tree performance by rootstock influence demands economic methods of vegetative propagation, for rootstocks do not breed true from seed. Propagation by hardwood cuttings is a useful method, when successful, as it is economical in material, ground and labour. The method succeeds well with some varieties, such as the plum Marianna, but with

others gives poor or inconsistent results. To succeed, a cutting must regenerate a root system, develop a shoot system, and grow large enough to take a scion-bud or graft. Conditions for life, rooting and growth may differ; for example, a sandy medium may promote rooting but retard later growth or cause drying out and death. Many rooted cuttings die, others live a year without forming roots. Fuller knowledge of these conditions and the special requirements of individual varieties, might lead to greater success with varieties of rootstock whose commercial use is at present restricted by difficulties in propagation. A review of the extensive work on hardwood cuttings has recently been undertaken by Garner for publication, so this paper will deal solely with recent work at East Malling Research Station.

Work at East Malling.—Experiments were started as early as 1919 by Dr. Knight and Mr. Witt, and the main results up to 1927 have been published (Knight, 1926; Knight and Witt, 1927), and these authors continued to lend their inspiration and experience to the work for some years. The present author became associated in this work at about that date and subsequently became responsible for its planning and continuance with the assistance of Mr. R. J. Garner, to whom best thanks are due for his collaboration and advice over matters of practical detail and actual execution.

Experimental.—A. Variety.—This is very important and presents some puzzling problems. For example, apple shoots root readily on the parent plant in stools without etiolation, but usually fail when detached as cuttings, while plum shoots usually fail to root on the parent plant unless etiolated in layers, but often succeed as cuttings. Closely related varieties, such as Myrobolan A and B, behave very differently as cuttings, one giving 3 per cent. and the other 90 per cent. success. In most of the experiments described below, several varieties were used and these often showed differential response. Attention will be drawn to these as they occur. In general this means that it is impossible to lay down rigid rules that apply equally to all varieties.

B. Condition of Cuttings when taken.—The internal condition of the cutting at the time when it is taken from the parent plant is of importance and may be influenced by a number of factors.

(*a*) *Age and General Condition of Parent Plant.* Sinha, working at East Malling, and using the plum rootstock Myrobolan B, took cuttings from four sources: (i) an old established hedge, (ii) an old established layer-bed, (iii) one-year-old "budded" layers, and (iv) one-year-old rooted cuttings. The results (Sinha and Vyvyan, 1943) showed that those from the hedge did best with about 80 per cent. rooted, those from one-year cuttings worst with about 28 per cent. rooted, while those from the layer bed and budded layers were intermediate with about 69 and 47 per cent. respectively. All the differences were significant. More recently work at East Malling has confirmed that hedge cuttings are better than those from a layer bed.

(*b*) *Portion of Shoot used.*—The shoots on a parent plant are often long enough to provide three or more cuttings; it is important to know whether all portions—base, middle and tip—are equally likely to make successful cuttings. Work on this was combined with that on the effect of etiolation, and the two factors can be conveniently taken together.

(*c*) *Etiolation.*—Etiolation of the base of the shoot is a promising method for inducing root formation and is the basis of the method of vegetative propagation known as "layering", as practised at East Malling (Knight and Witt, 1927). Etiolation can be achieved in various ways; the most convenient, from the practical standpoint, consists in making the young shoots grow out through a thin layer of soil, so that their bases are never exposed to light. A number of experiments were carried out with "etiolated" and "non-etiolated" cuttings with great apparent success. A typical result obtained in 1929-30 may be given as an example:

TABLE I.

PERCENTAGE ESTABLISHED IN ETIOLATED AND NON-ETIOLATED CUTTINGS.

	Common Mussel.	Brompton.
Non-etiolated ..	36%	15%
Etiolated	91%	85%

This and previous experiments, however, were not above suspicion, for, whereas the etiolated cuttings were from the bases of shoots, the non-etiolated cuttings were from the upper portions, and, moreover, from shoots whose bases had been etiolated. A further experiment was therefore carried out in 1933-34, and repeated in 1934-35, with the plum rootstock Common Mussel. For this purpose certain shoots were allowed to grow out fully exposed to the light, so that their bases were not etiolated, whilst other shoots were forced to grow out through a layer of soil, to provide etiolated bases. Two

cuttings, one basal and one higher up,were taken from each shoot. The percentage established in the four types of cutting are shown in Table II.

Etiolation of the base improved rooting in cuttings taken from the base but depressed it in those from the upper portion. This interaction between "etiolation" and "portion of shoot used" was statistically significant. When using this variety nothing is gained by etiolation of the base, unless only one (basal) cutting is to be taken. Sinha has repeated this experiment, but took three cuttings—base, middle and tip—instead of two from each shoot, and included a second plum variety—Pershore.

TABLE II.

EFFECT OF ETIOLATION OF BASE ON ROOTING OF BASE AND UPPER PORTION. PERCENTAGE OF CUTTINGS ESTABLISHED.

Treatment of Base.	1933-34.			1934-5.		
	Base.	Upper portion.	Mean.	Base.	Upper portion.	Mean.
Non-etiolated ..	33	41	37	38	38	38
Etiolated ..	49	9	29	75	20	48
Mean	41	25	33	56	29	43

His results (Sinha and Vyvyan, 1943) confirmed those given above, for Common Mussel, but Pershore behaved differently; here etiolation of the base improved rooting in all cuttings. They showed, however, that cuttings from the tips of shoots were of little use in either variety.

(*d*) *Ringing, notching and slitting on parent plant.*—The effect of ringing, notching, or slitting the shoots at various times in the autumn, and later taking cuttings with their basal cut at the position of the ring, notch, or slit, was tried in 1931-32, with a plum rootstock—Brompton, and an apple rootstock—No. II. Neither of these varieties normally roots well from cuttings. No conclusive results were obtained, for the percentage rooting was low under all treatments.

(*e*) *Time of taking and planting.* So long as the cutting remains attached to its parent plant, interchange of materials between the two is possible. Time of taking may therefore influence the internal condition of the cutting. The effect of time of taking was tried for seven seasons—1929-30 to 1935-36. The plum rootstocks Myrobolan B, a ready rooter, and Pershore, a shy-rooter, were used each season. The apple rootstock No. IX was tried for three seasons, and Common Mussel for two.

Time of taking inevitably involves time of planting; as some sort of check, though not a satisfactory one, certain cuttings taken at early dates were bedded-in in bundles in the sand and planted out at the same time as later takings. The percentage established for different times of taking and planting are given in Table III for Myrobolan B and Pershore. The values for the apple

TABLE III.

TIME OF TAKING AND PLANTING CUTTINGS. PERCENTAGE ESTABLISHED.

	Taken : Planted :	Aug. Aug.	Sept. Sept.	Oct. Oct.	Nov. Nov.	Jan. Jan.	B.S. B.S.	Sept. Oct.	Oct. Nov.	Oct. Jan.	Oct. B.S.	Jan. B.S.	Sig. Diff.
Myrobolan B	1929-30			70		64	16		59				
	1930-31			62	43	32	25		72	70	67		
	1931-32		2	15	82	80	80						
	1932-33	9	16	61	68	70	31						18
	1933-34			58	56	71	36			35	36		14
	1934-35			73		79	20			70	54	43	17
	1935-36			93		53	34	10		74	25		16
Pershore ..	1929-30			9		0	0		8				
	1930-31			7	0	0			7	2			
	1931-32			0	22	3	0						
	1932-33	0	6	9	5	1	4						
	1933-34			24	15	9	0			35	11		
	1934-35			13		0	0			5	3	*	
	1935-36			31			*	11		1	*		

* Not done.

stock were not worth including and Common Mussel behaved much the same as Myrobolan B. The results show great seasonal variation and are not very conclusive. In general they suggest that Myrobolan B and Common Mussel cuttings can be taken and planted with reasonable safety up to January, but Pershore cuttings are likely to be a complete failure if taken later than November. The apple rootstock gave very poor results; the highest value was 17 per cent. obtained for cuttings taken and planted in January, 1932. It showed, however, a surprisingly high "survival" rate, especially for cuttings taken in January; on one occasion as many as 79 per cent. were alive nine months after planting, though none had rooted. It might be worth trying special treatments, such as spraying with growth substances, during this period. In the last four seasons the experiments were laid out in blocks of randomized plots and statistical analysis was possible. This was done for Myrobolan B and the significant differences are shown in the last column of the table. Certain of the seasonal variations in response can thus be proved to be significant; for example, in 1933-34, the Jan./Jan. cuttings rooted better than the Oct./Jan. The values were 71% and 35% respectively. In 1935-36 the reverse was the case, the values being 53% and 74%. Examination of the meteorological records showed no obvious relation between rooting performance and the severity of the winter. One point of interest was revealed by observations on the cutting beds in June, 1935. A record was made of the number of cuttings that had developed shoots more than 5 cm. in length. The percentages with such shoots in Myrobolan B for the Oct./Oct., Oct./Jan., and Oct./Bud-swell* cuttings were 79%, 76% and 70% respectively, and for the Jan./Jan., Jan./B.S. and B.S./B.S. cuttings, 29%, 11% and 8% respectively. Thus the state of growth in June was dictated by the time of taking and not by the time of planting. These percentages, however, bore little relation to the final yield of established cuttings; for example, the June values for the Oct./Jan. and Jan./Jan. cuttings were 76% and 29%, the final values 70% and 79% respectively.

C. Effect of Treatment between Taking and Planting.—(*a*) *Removal of leaves.*—It is customary to plant hardwood cuttings with their top leaves on, as this is supposed to encourage rooting. To test this, a small scale experiment was carried out in 1933-34 with one plum rootstock, Common Mussel. A hundred cuttings were planted with leaves on, and a hundred with leaves removed. Twenty-seven of those with leaves rooted and only three of those without. An experiment on a larger scale was carried out in 1934-35, and repeated in 1935-36, with three varieties of plum rootstock. Here the effect of the number of leaves left on was examined. The results expressed as percentage rooted, are given in Table IV. Common Mussel rooted much better than in 1934 but showed no significant

TABLE IV.

PERCENTAGE ESTABLISHED: EFFECT OF NUMBER OF LEAVES LEFT ON CUTTING AT PLANTING UPON ROOTING PERFORMANCE.

	1935.				1936.			
Planted with:	Common Mussel.	Brompton.	Damas C.	Mean.	Common Mussel.	Brompton.	Damas C.	Mean.
3 leaves	54	26*	69	49	63	29	56	49
2 leaves	51	15	59	42	39	35	59	44
1 leaf	50	10	51	37	45	28	56	43
0 leaves	35	26*	34	32	43	14	29	28

Values bracketed or bearing * not significantly different.

response to the number of leaves left on—though the difference between no leaves and three leaves was nearly significant in 1935. Brompton rooted poorly and gave inconsistent results. Damas C gave the best and most significant performance, here cuttings without leaves rooted worse than those with the leaves left on. The mean values for the three varieties were about the same the two seasons. Cuttings with three leaves rooted better than those with none, but there were no significant differences between the values for three leaves and two leaves, or for one leaf and no leaf.

In 1936 the history of each individual cutting was followed to determine the relation between the time when the last leaf was shed and subsequent rooting performance. The main results are shown in Table V. Brompton, the variety that rooted worst, lost its leaves earliest. But within each variety there was a tendency for the cuttings that retained their leaves longest to root the worst; probably they became moribund early and lost the power of forming an abscission layer.

* By "Bud-swell" is meant the time in spring when the buds are swelling previous to breaking into leaf. This occurs earlier in some varieties than in others. BS/BS means cut and planted at "Bud-swell".

(*b*) *Injection with Growth Substances.*—A number of experiments were carried out to determine the effect of injection with various growth substances on rooting of hardwood cuttings (Pearse, 1939 ; Sinha and Vyvyan, 1943). In most of these there was no improvement in rooting. In one experiment, however, Sinha obtained a marked increase in the rooting of cuttings from two plum varieties, Common

TABLE V.

TIME OF COMPLETION OF LOSS OF LEAVES AFTER PLANTING AND ITS RELATION TO ULTIMATE ROOTING.

Completed loss of leaves in week ending :	Condition of cutting at end of season.					
	Common Mussel.		Brompton.		Damas C.	
	Rooted.	Dead.	Rooted.	Dead.	Rooted.	Dead.
23/10 ..			3	2		
31/10 ..	1	2	26	49	23	17
6/11 ..	67	56	40	101	99	66
13/11 ..	48	63	4	15	12	23
20/11 ..	1	2				

Mussel and Pershore, by injection with 20 p.p.m. indolebutyric acid. This suggests that success with these substances depends on some factors not yet identified and that further work on these lines is required.

(*c*) *Injection with other Substances.*—Knight (1927) tried injection with various substances and found most of these harmful. In some cases, however, he got an improvement with sugar, though the results were not consistent and were apparently related to the time the leaves were retained after planting. A small scale experiment was carried out in 1932-33 with the plum rootstock Pershore and the apple No. I. Forty cuttings of each variety were injected with 5 per cent. sugar solution, forty with distilled water and forty planted untreated as a control. The apple failed almost completely. In Pershore, injection with sugar significantly reduced rooting, the values were : sugar 10%, water 28% and control 30%. The time of leaf-fall from the cuttings was recorded ; those on cuttings injected with water were retained longest, cuttings injected with sugar lost theirs as quickly as the controls.

Various experiments were also carried out with injection, or other treatments, with dormancy breaking substances such as thiourea, but no improvement in rooting was observed.

(*d*) *Other Treatments before Planting.*—Various other treatments, such as ringing, notching and wounding, dipping in wax, and storage for a period at low temperatures, were tried but gave no results or were in some cases harmful.

D. Conditions after Planting.—(*a*) *The Medium.*—Knight (1927) showed that good aeration is important and that rooting is therefore better in sand than in soil. Unfortunately cuttings in sand often die from lack of moisture in the summer, or remain small from lack of food materials. The obvious answer seemed to be watering and a supply of fertilizers. Watering, however, he found was of little effect ; it did some good in dry autumns but was actually harmful in wet seasons. Some unpublished work of his on fertilizers gave negative results. In 1928-29 a new method was tried ; this consisted in providing a three inch layer of sphagnum moss, underneath the sand of the cutting-bed, which might act as a water-retaining sponge. Three varieties of plum were planted in this sand over sphagnum and, as a control, in sand without sphagnum. The results, given in Table VI, were encouraging ; in every case better rooting and greater size were obtained over the sphagnum.

In a further experiment, started in 1929-30, and continued until 1934-35, there were three cutting beds, end to end, separated by vertical slates. The centre bed was the control and had sand over soil. In the other two a " humus layer " was inserted between the sand and the soil ; in one bed this was sphagnum moss, in the other it was spent hops. Five rows of twenty cuttings of each of three

TABLE VI.

PERCENTAGE ESTABLISHED AND MEAN SIZE IN SAND AND IN SAND OVER SPHAGNUM.

	Control (sand).		Sphagnum (under sand).	
	Percentage rooted.	Size.	Percentage rooted.	Size.
	%	cm.	%	cm.
Damas C	24	15	48	25
Pershore ..	0	—	8	14
Common Mussel ..	14	15	33	29

varieties were planted in each bed season. Common Mussel and Pershore were used each season. A third plum variety, Damas C, was used for the first three seasons; it was then replaced for one season by the apple rootstock No. I and for the last two seasons by the plum Myrobolan B. The beds were not disturbed or renewed during the six seasons. The results are shown in Table VII.

TABLE VII.

EFFECT OF LAYER OF "HUMUS" UNDER SAND.

		Percentage established.			Mean size.		
		Sphagnum.	Control.	Spent Hops.	Sphagnum.	Control.	Spent Hops.
Common Mussel	1929-30	89	73	2	29 cm.	18 cm.	28 cm.
	1930-31	84	38	50	27 ,,	16 ,,	47 ,,
	1931-32	75	43	69	40 ,,	15 ,,	60 ,,
	1932-33	44	31	34	39 ,,	11 ,,	41 ,,
	1933-34	48	30	45	12 gm.	9 gm.	15 gm.
	1934-35	39	46	21	20 ,,	12 ,,	42 ,,
Pershore ..	1929-30	62	27	7	18 cm.	17 cm.	9 cm.
	1930-31	18	12	21	35 ,,	18 ,,	35 ,,
	1931-32	64	19	60	25 ,,	15 ,,	39 ,,
	1932-33	46	24	49	30 ,,	10 ,,	87 ,,
	1933-34	35	7	24	23 gm.	14 gm.	36 gm.
	1934-35	38	33	38	17 ,,	15 ,,	48 ,,
		47	20	33			
Damas C ..	1929-30	53	46	65	42 cm.	19 cm.	31 cm.
	1930-31	82	38	75	33 ,,	17 ,,	37 ,,
	1931-32	85	86	93	33 ,,	16 ,,	49 ,,
No. I ..	1932-33	18	0	13	22 cm.	—	29 cm.
Myrobolan B	1933-34	59	51	56	27 gm.	12 gm.	36 gm.
	1934-35	52	37	19	28 ,,	16 ,,	42 ,,

In almost every case a higher percentage of cuttings rooted over the "humus" layer than in the control, and in most cases the sphagnum gave a slightly higher value than the spent hops. In the first season, 1929-30, very low values were obtained in Common Mussel and Pershore over spent hops. It was found, however, that the cuttings had been planted too deep and were actually in contact with the hops; this was probably the cause of the trouble.

In every case the cuttings were larger, and often much larger, over the "humus" layer; especially over the spent hops. The insertion of a layer of humus below the sand of a cutting bed seems therefore a possible method for improving rooting performance. In practice, however, the best plan would be to look for some place where such a layer normally exists.

The effect of a "humus" layer below soil was tried with one plum variety, Common Mussel, for two seasons and proved harmful.

(*b*) *Shelter from Wind.*—As water loss by evaporation and transpiration may be increased by air currents, the effect of sheltering the cutting bed from the wind was tried for two seasons—1928-29 and 1929-30. The wind screen was constructed of three thicknesses of hop lewing, or coconut fibre matting. The number of established cuttings each season and their mean size in 1928-29 are shown in Table VIII.

TABLE VIII.

EFFECT OF SHELTERING CUTTING BED WITH SCREEN OF HOP LEWING.

	Percentage established.				Mean size.	
	1928-29.		1929-30.		1928-29.	
	Control.	Shelter.	Control.	Shelter.	Control.	Shelter.
Common Mussel ..	22	19	58	49	28 cm.	29 cm.
Pershore	3	5	28	21	8 ,,	10 ,,
Damas C	31	19	79	72	14 ,,	20 ,,
Myrobolan B	86	58	58	64	49 ,,	35 ,,
St. Julian A	34	9	55	47	15 ,,	15 ,,

There was a marked seasonal effect ; performance was far better in 1928-29 than in 1929-30. In both seasons, however, the sheltered plot usually gave the poorer performance.

Shelter from wind by a screen of " hop lewing " was thus of no benefit or even harmful ; possibly shelter by means of a living hedge might be better.

(*c*) *Effect of shading with Muslin.*—Shading with muslin was tried with five varieties of plum rootstock in 1930-31. The results were inconclusive as the percentage established was very low in both plots. The cuttings in the shaded plot made less growth than those in the unshaded plot.

(*d*) *Combined effect of Shade and Humus Layer.*—The shade experiment was repeated in 1931-32 and 1932-33, using beds in which a layer of spent hops had been inserted under the sand. The results were again inconclusive. In St. Julian A the percentage established was higher in the shaded than in the control plot both seasons ; in Myrobolan B and Pershore it was higher in the shade in 1931-32 and in the control in 1932-33. The general level of performance was much better both seasons than that found in the plots without a humus layer in 1930-31 ; this seems a further indication of the value of a humus layer, but may, of course, have been in part a seasonal effect.

Discussion.—Varieties show great difference in rooting performance when propagated by hardwood cuttings ; some root readily, others only produce an occasional rooted cutting. But any variety that produces a single rooted cutting shows thereby that it possesses the power to root, provided certain necessary conditions are fulfilled. An easy-rooting variety is one that requires conditions normally present, a shy-rooter is one that requires conditions rarely realized. These conditions may be internal or external, and those required for one shy-rooter may differ from those required for another. If the nature of a required internal condition were known, it might be easier to establish, but in practice it is often easier to establish the condition than to find out its nature. For example, in Myrobolan B, hedge cuttings have rooted better than those from a layer bed and some internal factor must be involved, but it is easier to establish the hedge than to determine the nature of the factor. The internal factors can be varied by using parent plants of different ages, different methods of cultivation, different methods of pruning, or by local treatments such as ringing, etiolation, bending, or by using different portions of the plant.

Although the success of an occasional cutting shows that the requisite conditions can exist, it does not necessarily mean that they can be established, in a sufficiently large portion of the plant, to provide cuttings on an economic scale. Consideration of the response of shoots of Common Mussel to etiolation will make this clear. In unetiolated shoots, cuttings from the base and from the middle both showed the same moderate rooting capacity. Etiolation of the base caused a great increase in the capacity of the basal cutting but a corresponding decrease in that of the middle cutting. This suggests that some substance, possibly a growth substance, is present in the shoots and must reach a certain minimal concentration for rooting to occur. In unetiolated shoots the substance would appear to be uniformly distributed and to reach this minimal value in a certain proportion of the shoots. Etiolation of the base would appear to concentrate the substance in the basal portion at the expense of the upper portion so that the minimal value would be reached more frequently in the base and more rarely higher up. In a variety in which the general level of concentration was even lower than in Common Mussel, the minimal value for rooting might rarely be attained in any shoot. Treatments, such as etiolation, might cause local accumulations and result in some improvement in performance, but this would be limited by the total amount of the substance present. Real improvement to an economic value could only be attained by inducing a greater production of the substance, or by introducing it artificially. It is not suggested that this is an exact picture of what happens or of the cause of varietal differences in rooting capacity ; it is meant rather to show that the occasional rooting of a cutting, and the occasional slight improvement in rooting as a result of treatments, does not necessarily imply that rooting on an economic scale can be attained. The results of the experiments described above show that some improvement in rooting performance can be attained in almost every variety tried. In a shy-rooter the improvement may not be sufficient to make hardwood cuttings an economic method, but in moderate-rooters it may be just sufficient to turn the scale. Even the difficult Pershore, under some treatments, occasionally produced a yield of over 60 per cent. established cuttings, which would be economic if it could be attained every time. Source of material, portion of plant used, time of taking and number of leaves left on the cutting, all seemed of some importance, but the most outstanding improvement was obtained by the insertion of a layer of humus under the sand of the cutting bed. Humus under loam had a harmful effect. Cutting beds of this kind can be constructed artificially, as was done in these experiments, but natural soil conditions fulfilling these requirements do occur, and for production of cuttings on a commercial scale, it would be better to use these.

Summary.—Experiments on rooting in hardwood cuttings, extended over several years are described. Great varietal differences in rooting capacity were found. Seasonal variation in performance was very marked. Source of material proved important ; in Myrobolan B, cuttings from a hedge rooted best. In one variety, Common Mussel, etiolation of the base of a shoot improved rooting

in the basal cutting but depressed it in a cutting taken higher up. Shelter from wind and shading with muslin were usually harmful. The greatest improvement in rooting and in size was obtained by inserting a layer of " humus " (sphagnum moss or spent hops) under the sand of the cutting bed.

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SPRAYS TO CONTROL PRE-HARVEST DROP OF FRUIT

By M. C. VYVYAN

Introduction.—Previous reports (Vyvyan, 1941 and 1942) have shown that dilute sprays of the synthetic growth substance alpha naphthalene acetic acid caused a considerable reduction in the pre-harvest drop in the four varieties of apple tried. This has confirmed for this country results already found in the U.S.A. and elsewhere. Further experiments were carried out in 1942 and will be described below. Two varieties were used, the pear Conference and the apple Bramley's Seedling. In the case of the apple two closely related substances and two times of application were tried.

Conference Pear.—*Plan of Experiment.*—Seven pairs of 20-year-old trees were used, the two trees of each pair being next one another in the same row. One tree in each pair, selected at random, was sprayed with 4 parts per million alpha naphthalene acetic acid on the 14th September, the other was left unsprayed as a control. All drops, including those that had fallen before the date of spraying, were counted and removed from under each tree on the 21st September. Subsequent drops from each tree were picked up at intervals of a few days, separated into good and bad fruit, counted, and the weight of the good determined. The last count of drops was made after the fruit on the trees had been picked, and included the bad fruit thrown down at the time of picking. The fruits were picked on the 8th October.

Table I.

Conference Pear.

Accumulated drops of good and bad fruit from unsprayed trees and trees sprayed with 4 parts per million alpha naphthalene acetic acid. Expressed as percentage of crop on tree on 21st September.

Up to:	Unsprayed.		Sprayed.	
	Good.	Bad.	Good.	Bad.
23rd September ..	0·9	0·2	0·1	0·0
25th ,, ..	1·7	0·4	0·1	0·2
28th ,, ..	3·3	0·6	0·3	0·3
30th ,, ..	5·3	0·9	0·5	0·5
2nd October ..	7·3	0·9	0·8	0·7
5th ,, ..	11·3	1·1	1·1	1·1
6th ,, ..	14·0	1·3	1·2	1·2
8th ,, ..	18·4	2·2	2·0	2·8

Results.—The accumulated drops at successive dates of good and bad pears from unsprayed and sprayed trees are shown in Table I, where they are expressed as percentages of the number of fruit on the trees on the 21st September. The percentage drop of good fruit was about ten times as great from unsprayed as from sprayed trees, but the drop of bad fruit was about the same from both. Unsprayed trees lost 20·6% of their fruit and of this 18·4% was good fruit, and the remaining 2·2% bad fruit. Sprayed trees lost only 4·8% altogether and only 2·0% was good, the remainder, 2·8%, being bad. Thus the spray kept the good fruit on but allowed the bad to drop. This represents a 20% gain in

crop of good fruit ; for every 5 bushels obtained from unsprayed trees, 6 bushels would be obtained from sprayed trees. Spraying was therefore thoroughly well worth while.

Bramley's Seedling Apple. -*Plan of Experiment.*—Forty-eight mature trees were used, arranged in six blocks of eight. Two trees in each block were left unsprayed as controls, three were sprayed with alpha naphthalene acetic acid and three with the closely related alpha naphthalene acetamide, which some workers have found as effective as the acid and possessing certain advantages. In each case, one tree was sprayed early, on 14th September, one late, on 2nd October, and one on both occasions. All sprays were used at a concentration of 6 parts per million. All drops already under the trees were removed at the start of the experiment, and counted to provide some measure of the drop before the sprays were applied. Subsequent drops were collected from under each tree at intervals of a few days, and counted and weighed. The apples were picked on the 18th October.

Results. Inspection of the data has shown that the number of fruit dropped during the month before picking was less, even in the controls, than the number found under the trees at the beginning of the period. This shows that, in this season at any rate, the drop tended to occur early. Inspection also showed that the initial number of fruit on a tree, estimated by summing the number picked and the number dropped, varied greatly. The range was from about 200 fruit to nearly 1,900. There was a strong indication that trees with a small initial number of fruit tended to lose a larger proportion of their fruit than those with a large initial number. It will be necessary, therefore, to examine the data statistically to determine how far this tendency persisted after the application of the sprays.

Although final conclusions must be postponed until this examination is completed, certain general indications may be stated. The early spray, put on in the middle of September, was fairly effective whichever substance was used ; the later spray, put on at the beginning of October was less effective. The gain in crop from the early spray was about 20 per cent., that is, some six bushels were got from the sprayed trees for every five from the unsprayed. As the average crop worked out at about six bushels per tree, this would be a substantial gain on the basis of an acre of trees. As a large part of the drop occurred before the early spray was put on, and as the early spray had more effect than the later spray, it is possible that spraying at an even earlier date would have given better results.

Summary.—A 20 per cent. increase in crop was obtained in Conference pear by spraying the trees with 4 parts per million alpha naphthalene acetic acid three weeks before the time for picking. An increase of about the same order was obtained in Bramley's Seedling with a spray of the same substance and with alpha naphthalene acetamide put on at 6 parts per million five weeks before picking. In the apple a later spray was not so effective and there are indications that an earlier one might have been better.

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PLANT PATHOLOGY

A LEAF CURL DISEASE OF RASPBERRY IN SCOTLAND*

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The purpose of this article is to warn raspberry growers of recent serious and increasingly widespread outbreaks of a hitherto unidentified disease in plantations of *Norfolk Giant* variety in the Angus and Perthshire districts of Scotland, and to suggest precautionary measures against it.

This disease, as its provisional name implies, is easily recognized by a pronounced downward curling of the leaves of the affected stools. On the new canes, when 12-14 in. grown (i.e. late May to early June) and onwards, the uppermost leaves curl first, followed progressively by the older leaves until all but the oldest basal leaves are tightly curled. A downward curving of the leaf stalk and midribs is the earliest stage of this curling process, which later involves every part of the leaf (see photograph). With their curling the leaves assume an abnormally dark-green colour, often with a waxy look and their stalks appear translucent or " water-soaked ". The fruit laterals also develop similar symptoms (which in advanced cases may appear before those on the new canes and as early

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as mid-May) to which is added a coarse yellow-green mottling of some leaves somewhat reminiscent of mosaic-disease, from which, however, the present disease is quite distinct. Leaves and stems on all canes thus affected are found to be extremely brittle, snapping off on slight pressure.

Stools showing the above symptoms rapidly die, and are completely dead not later than during the season next following that in which curling of the foliage first appears. The rate of spread, while

[*Photo C. E. Foister*

A new cane of Norfolk Giant showing advanced leaf curl.

not epidemic like certain fungus diseases, is such that in a few years large patches of dead cane cause considerable alarm.

In recent experiments at East Malling this disease was graft-transmitted from Norfolk Giant to healthy stools of the old *Baumforth's Seedling B*, and induced on them the symptoms of the so-called "Baumforth's Disease" which was considered mainly responsible for the complete failure and demise of this variety in Scotland some fifteen years ago, and the cause of which has remained obscure. From

these results and from similar transmissions of the North American "Leaf Curl" virus disease of raspberries to the same variety, made by one of us (Harris) in Canada in 1933, it is now assumed that the present trouble in Norfolk Giant is an infectious virus disease identical with the former "Baumforth's Disease" and closely resembling North American "Leaf Curl". The natural agent of spread has yet to be determined. The problem of the link between the disease in Baumforth's Seedling and its recent appearance in Norfolk Giant is being studied. A possible explanation is provided by recent observations indicating that the Lloyd George variety may carry the disease and therefore provide an ubiquitous source of infection for the highly susceptible Norfolk Giant. Pending confirmation of this possibility the present evidence is considered sufficiently strong to warrant immediate precautionary measures based on its assumption.

This disease has not yet been reported in English plantations of Norfolk Giant and searches in English sources of certain Scottish stocks of this variety have so far failed to reveal the disease in these localities. This possible limitation of serious outbreaks of this disease to the Scottish districts is being further tested and studied.

Growers are strongly advised to search their Norfolk Giant plantations frequently for this disease and, if they locate an outbreak, to adopt the following precautionary measures to check its spread:

(1) Every diseased or suspect stool should be removed from the plantation entirely and burnt without delay.

(2) New plantings of Norfolk Giant should only be made with cane from sources which the grower is satisfied are free from the disease.

(3) Plantations of Norfolk Giant especially those destined for cane propagation should be isolated as far as practicable from those of the Lloyd George variety, particularly from stocks of that variety which have been propagated in Scotland for some years.

In cases of any doubt or difficulty in identifying the disease, and on the appropriate action to be taken, advice should be sought from the Plant Pathologist to the Scottish Department of Agriculture or the County Horticultural Officers.*

Summary.—A recently identified leaf-curl virus disease is briefly described as it occurs on the Norfolk Giant raspberry in the Scottish districts of Angus and Perthshire. Precautionary measures to check its spread are suggested.

SUN SCALD OF FRUITS†

By M. H. MOORE and W. S. ROGERS

SEVERE Sun Scald of fruits of various kinds, including peach, apple, and tomato, was observed in Kent during the first week of September. The injury followed a period at the end of August when unusually high temperatures (max. F. 84° on 27th, 86° on 28th, 82° on 29th) with long spells of sunshine (9·2 hours on 27th, 10·8 hours on 28th, 6·3 hours on 29th) were recorded at East Malling Research Station. In addition, the Relative Humidity was very high on the 24th (94%), 25th (92%), 30th (84%), and 31st (92%), though it is not certain whether the incidence of the injury has any connexion with high Relative Humidity or, indeed, with the presence of moisture on the skin of the fruit at the time of injury. All fruits injured, to whatever degree, were those fully exposed to the sun's rays without any protection from the foliage.

A fine crop of Peregrine peaches on a south wall at East Malling Research Station was greatly reduced in value. The fruits most severely injured showed a soft, round or oval, flattened area, discoloured reddish-brown, in some instances 2 in. or more in diameter, and immediately surrounding it a narrow area of exposed flesh where the healthy tissue had separated from the affected area presumably at the period of rapid expansion when the fruit was turning ripe. Numerous wasps and bees were feeding on the exposed flesh, and some peaches had been eaten to the stone. Brown Rot (*Sclerotinia fructigena*) soon set in and completed the destruction. Some fruits, less severely damaged, showed only a roughly circular or oval, yellowish-white area on the exposed side, and the skin was not broken. There were all grades between those very slightly and those very severely affected (see Fig. 1), while many fruits, perhaps half or more of the crop of several hundreds, were apparently unaffected.

At the same time as the damaged peaches were first observed (3rd September), many similarly damaged apples were found on the trees at the Research Station farm. The main difference between the peaches and the apples lay in the rupturing of the skin and the exposure of the flesh, a character

* Raspberry growers in England and Wales who suspect an outbreak of this disease in their plantations are asked to communicate with East Malling Research Station.

† Reprinted, by kind permission, from the *Gardeners' Chronicle*, CXII, Oct. 1942, 166-67, with an addendum.

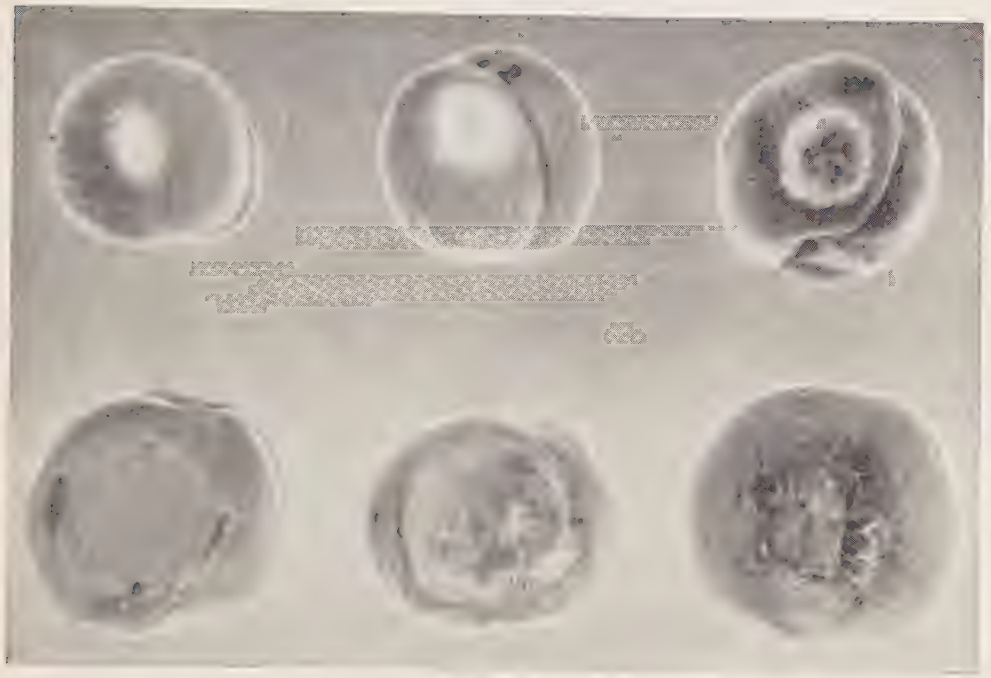

FIG. 1

Sun-scald of peaches.

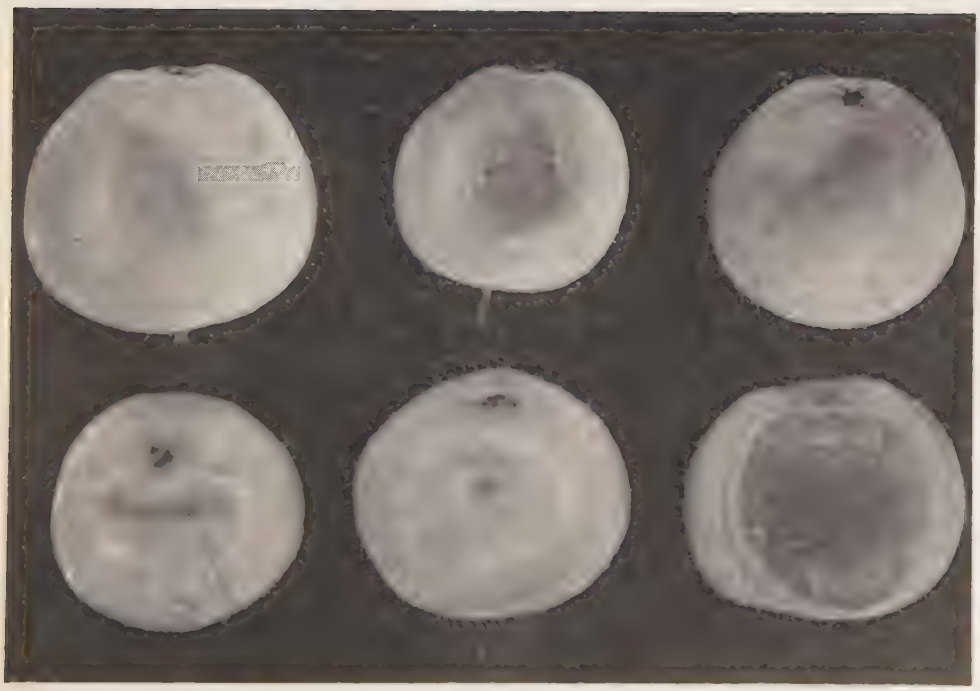

FIG. 2

Sun scald of apples.

Top line : Allington Pippin with typical bruise-like damage.
Bottom line : Newton Wonder with differing symptoms, the bruise type on the left.

not seen on any affected apple : the main similarity lay in the presence of a flattened, sometimes sunken, discoloured brown area on that part of the fruit exposed roughly at right angles to the rays of the sun at midday. Varieties showed interesting differences in their manifestation of the trouble. Newton Wonder, Allington Pippin, and Bramley's Seedling were the most commonly affected ; a few affected fruits of Lane's Prince Albert were found, and very few of Cox's Orange Pippin and Worcester Pearmain. On Newton, Bramley's, and Lane's, the brown flattened area was often surrounded by a narrow halo of pale green or greenish-yellow, and immediately outside this was a further, vivid halo of red or orange-red, the inner edge of which was fairly sharply defined, with the outer edge diffusing into the normal greenish-yellow of the fruit (see Fig. 2, bottom line). The visual effect of this ensemble was most striking, giving the impression of a large, fantastic eye up to 2 in. or more in diameter ; once seen, it could scarcely be mistaken for anything else. The central area was mostly dark brown and seemed as if baked or scalded. After a day or so the dark colour became much paler, especially with apples brought indoors, and the area, at first quite firm, softened. Invasion by fungi soon followed, Brown Rot (*Sclerotinia fructigena*) completing the destruction as with the peaches. Nearly all severely damaged fruits remaining on the trees ultimately succumbed to Brown Rot, doubtless helped by the working of the softened area by wasps, flies, etc. Where Brown Rot did not supervene, the halo round the brown central area on Bramley's Seedling became bright orange-yellow two or three weeks after the injury was first seen. Slight damage on Newtons, Bramley's, Lane's and Cox's took the form of small, roughly circular, pale yellow or whitish areas (later turning orange-yellow), sometimes slightly flattened, firm, and perhaps rugose, mostly with a halo either faint, or as a clearly marked flush of red. Occasionally the area was merely a flush of red with a faint pale halo. Allington showed very characteristic symptoms quite different from those typical of Newton and similar varieties, yet occasionally seen on them too. The Scald area was suffused, like a bruise, often considerably sunken, variable in colour though mostly dark red or purplish-red, and typically forming an arc, but sometimes extending as a circle right round the apple and enclosing a healthy area (see Fig. 2, top line). This kind of Sun Scald has hitherto been noticed, though not frequently, in other seasons. Worcester Pearmain showed merely a slightly sunken area of intensified deep red in the normal red of the exposed skin, but in general form the symptom was more nearly that of Allington than of Newton.

In all instances of severely affected apples examined, whatever the variety, the flesh beneath the affected area was discoloured various shades of brown, often very dark, usually in a sharply defined corresponding area, and penetrating sometimes very deeply towards the core. The flesh was disintegrated and, where fairly dry, had the appearance and consistency of a sponge. Some Allingtons completely ringed by a band of Scald had a corresponding band of this disintegrated brown flesh running right through the apple, thus separating into two portions the apparently normal tissue of the rest of the fruit. Many Bramley's that first showed the brown, flattened area subsequently developed a wide, brown band of Scald concentrically around and some distance away from the original injury. This band was continued into the flesh, often very deeply, and was sharply defined and very like the Allington type of injury. Water-core was found to be concomitant with Sun Scald in many cases.

Knight (1922)* recorded Sun Scald on Rhode Island Greening and Baldwin apples, and stated that " Sun Scald is the name usually applied to excessive burns that may result from late summer spraying when the sunshine is bright and the atmospheric temperature high ". He sprayed with lime-sulphur and lead arsenate on 4th and 5th August, 1914, and records that " on both days the sunshine was very hot and the temperature ranged from 90° to 100° F. All apples that were well covered with the spray and then exposed to the sunshine for three or four hours developed a characteristic burn." The Sun Scald attracted attention four days later, on 9th August. His description of the Scald agrees in some respects with that recorded above on apple, but on his Baldwins the brown colour penetrated " to not more than one-eighth inch ", and " the burned tissue turned brown and dried out, only to be followed later by the formation of large cracks in the dead tissue ". Knight's implication that the occurrence of Sun Scald was connected with spraying is interesting, for there was clearly no connection in the present instances, spraying of apples having ceased early in July. The common factor, however, might be the presence of moisture on the surface of the fruit ; moisture supplied by spraying in his case and by atmospheric conditions in ours. Although there is no proof of this, since injury was not anticipated and the surface condition of the fruit was not specially noticed during the hot period at the end of August, it can in fact be stated that moisture, in the absence of rain, persisted for an unusually long time on vegetation in general during that period.

Affected apples showing similar symptoms have been received from several other localities, including Oxfordshire. Affected Conference and Beurré Superfin pears were observed on cordon trees on a south fence in a private garden in Maidstone, the colour of the abnormality in this case being

* Knight, H. H. (1922). " Studies on Insects affecting the Fruit of the Apple." *Cornell Univ. agric. Expt. Sta.*, Bull. **410**, Ithaca, N.Y., 449-98.

predominantly orange. Outdoor tomatoes, too, have not escaped, several instances of affected fruits having been noted in the Maidstone district. On these, the damaged areas were very similar to some of those seen on Newton Wonder, Bramley's, and Lane's apples except that the high colour contrasts were not nearly so pronounced. The tomatoes were affected before they ripened and the damaged areas were irregular in shape, yellowish, slightly sunken to form saucer-like depressions, hard, dry, and corrugated.

In gardens, and especially for peaches on walls, it might be worth shading fruits by some simple means (e.g. with muslin) during very hot sunshine, but on a large scale any artificial measures are clearly impracticable. The presence of plenty of healthy foliage consistent with balanced growth and the ability of the plant to ripen its fruits normally is the best safeguard.

The writers are indebted to Mr. R. J. Garner for facilities to observe the damage on peaches, to Miss E. C. Thompson for kindly taking the photographs, and to Mr. H. C. Chapelow for the meteorological data.

Summary.—A description is given of Sun Scald symptoms on peach, apple, and tomato, first seen a few days after a short period of very high temperatures with many hours of sunshine, at the end of August, 1942.

Addendum.

Ware ("High temperature injury on the growing apple," *Gdnrs' Chron.*, 1932, **92**, pp. 287-88) described and illustrated almost identical symptoms of Sun Scald on Bramley's Seedling and Newton Wonder. He attributed the injury to "high temperature during growth, probably coupled with some moisture or drought condition".

In preliminary experiments made in collaboration with Miss K. Brewer of Maidstone since the publication of our field observations, the exposure of Newton Wonder apples, picked from the tree, to a source* of infra-red rays 2 ft. away for six hours caused scalding of some, but not all, fruits, very similar to that observed under natural conditions in the field. Similar exposure to a source† of ultra-violet rays 3 ft. away for up to 24 minutes showed no effect. The presence or absence of added moisture on the skins of the fruits at the time of exposure did not influence the result.

A FIELD TRIAL OF MEASURES DESIGNED FOR THE CONTROL OF BACTERIAL CANKER OF VICTORIA PLUM TREES

By H. B. S. MONTGOMERY, M. H. MOORE and T. N. HOBLYN

Historical.—Bacterial Canker has long been recognized as one of the most serious diseases of certain varieties of plums. In some of the plum rootstock trials at East Malling this disease took severe toll of the trees especially in the early years. The incidence of the disease, then known as "Die Back", in some of these trials was described by Amos, Hatton and Mackenzie (1925) and it was then shown that certain varieties, particularly Victoria, were highly susceptible, whereas others were resistant. Wormald (1931) summarized the knowledge that he had accumulated since 1924 from observations in the Station's plantations. He described the symptoms of the disease in detail and confirmed that the causal organism was a bacterium not previously described, which he named *Pseudomonas mors-prunorum*. The cankers were produced mainly on the stem, either partially or completely girdling it and extending more or less from ground level to just above the crotch. The cankers were initiated most readily in autumn and progressed during winter and early spring, but became evident only when secondary thickening began in spring. During summer, especially late July and August, the organism persisted on the foliage producing a brown leaf spot, which later dried up and fell out leaving a small round hole—the so-called "shot-hole" symptom. As a rule the organism in the cankers died out during the summer, but fresh infections could occur on the stems in autumn. All the available evidence showed that wounds were necessary for stem infections.

Based on the evidence at his disposal, Wormald suggested possible measures for the prevention and control of the disease. These were (i) the use of resistant varieties as "stem-builders" for valuable susceptible ones, a method which had been tried successfully in America in attempts to combat Fireblight in pear trees; (ii) the avoidance of pruning during the period October to December when infection of the stems and branches most readily occurred; (iii) spraying the stem and crotch

* A 500 watt medical infra-red lamp.

† A portable mercury-vapour lamp giving 28 per cent. ultra-violet rays, 20 per cent. visible rays, nd 52 per cent. infra-red rays.

with a bactericide during this danger period ; and (iv) the control of the leaf-spot stage by spraying with a bactericide during the summer months.

In 1932 a start was made to design experiments specifically for the prevention or control of this disease, the treatments being based upon Wormald's suggestions. The variety Victoria had always proved most susceptible and the main object of the trials was to find a means of controlling the disease in this valuable commercial variety. The methods suggested fell naturally into two categories. In the first, the measures were in the main pomological, the building of resistant frameworks upon which the susceptible variety could be worked, and pruning at a safe time of year. In the second the causal organism was to be more directly attacked by spraying. The methods in the first category were naturally to be preferred, since although they might entail a more expensive tree and some modification of the ordinary pruning routine, these drawbacks would be small compared with the labour and cost of spraying. In every case prevention is better than cure.

Although the main experiment embraced treatments designed to test all these measures, indeed this was one of the first complex exploratory trials laid down at the Station, it is simpler to consider the experiments under the two headings, viz. attempts to control the disease (1) without spraying, (2) by spraying.

Attempts to control the disease without spraying.

1. Stem-builders.

Six commercial varieties were selected as stem-builders upon which to work Victoria. Two of these, Utility and Purple Egg, had been outstandingly resistant to the disease as scion varieties in previous field trials, while the other four, Warwickshire Drooper, President, Yellow Egg and Denniston's Superb had shown some measure of resistance. These were all worked upon a single rootstock, Myrobolan B, for comparison with trees on the same rootstock with both stems and heads of Victoria. Trees with stems of Myrobolan B were also included in the trial, since, if successful, such trees on their own roots would be cheaper to produce. Some of these were run up from unworked rootstocks, while the remainder were worked in the same way as the other stem-builder varieties. Rootstock *per se* had not been found previously to have a marked influence on the disease, but as a check on this factor the variety Yellow Egg (Pershore) was included worked both upon itself and upon Myrobolan B.

Raising of tree material.—The trees were raised by budding the stem variety on to rooted layers of Myrobolan B in the normal way, in 1932. The resulting one-year-old trees were headed at 5-6 feet and each was allowed to form three branches in the ensuing season (1934) to serve as a head. In March, 1935, the top scion variety (Victoria) was grafted on to these branches about 6 inches from their point of origin. The trees thus took four years to raise from the time the rootstocks were planted.

Design of Experiments.—As is often the case, the numbers of trees of the different combinations available for planting out were not the same and the design of the experiment was to some extent dictated by this factor. It was possible to find at least 36 trees each of seven of them, all on Myrobolan B roots :

Victoria.
Myrobolan B, unworked (i.e. on own roots).
Myrobolan B, worked (i.e. stem budded on rootstock).
Purple Egg.
Denniston's Superb.
Warwickshire Drooper.
Utility.

These trees were all included in Trial A. They were planted out at 15 feet square in the spring of 1936, in nine blocks, of 28 trees each, arranged in the form of a 3 × 3 square. Each of these blocks contained four rows of seven trees, each row having one tree of each of the seven different kinds of tree arranged at random within it. This generous replication allowed of the inclusion of pruning and spraying treatments within the framework of the same experiment, as will be seen later. Fewer trees were available of the three remaining combinations of rootstock and stem variety, President and Yellow Egg on Myrobolan B, and Yellow Egg on Yellow Egg, and these, together with trees with Victoria and Warwickshire Drooper stems, were included in Trial B. In this trial the five different kinds of tree were arranged in twelve randomized blocks. No subsidiary treatments were included in this trial, but the trees all received spring and autumn sprays of Bordeaux mixture and were pruned in May. They were planted at the same time as Trial A and at the same distances.

2. Time of Pruning.

Following Wormald's finding that the trees were most vulnerable during the months of October, November and December, it was decided to compare the effect of pruning in late September to early

October with that of pruning at a safer time of year. The month chosen was May, because this was as near to the safe summer period as was practicable. Accordingly, within each of the blocks of 28 trees in Trial A, two out of the four trees with each stem-builder variety, selected at random, were pruned in October, while the other two were pruned in May. In Trial B all the trees were pruned in May. The actual methods of pruning were those normal for plums, except that leader-tipping was continued until the sixth year after planting, which is rather longer than is usual. After the first season, some of the leaders were cut back annually from one-third to a half, others being left full length for fruiting. Where necessary, branches have been thinned out and crossing branches removed. In May, 1936, the feathers were removed from the lower part of the stem and below the head, to allow of girth measurements and staking. In the following May, 1937, they were pinched back. In the summer of 1938 all were finally removed. In this respect trees whose branches were pruned in autumn and spring were all treated alike.

Results.

(*a*) *Effect upon the disease.*

Individual tree records were made of stem cankers, branch cankers, leaf spotting, Rust (*Puccinia Pruni-spinosae* Pers.) and defoliation. The records of leaf symptoms (viz. leaf spotting, Rust and defoliation) were made in categories from 0 (or 1) to 5 (maximum symptoms).

The effectiveness of certain varieties in providing resistant stems is most clearly shown in Tables I and II, which set out the numbers of trees with stem cankers and the numbers of trees that died for each variety.

TABLE I.

TRIAL A. NUMBERS OF TREES (MAX. 36) CANKERED AND DEAD FROM 1937 to 1942.

Stem variety.	Trees cankered.	Trees dead.
Denniston's Superb	19	4
Purple Egg	15	(1 dying, 1942)
Myrobolan B (worked)	0	0
Myrobolan B (unworked)	2	1
Warwickshire Drooper	3	0
Victoria	16	3
Utility	4	0

The proportions of diseased and of healthy trees for the different kinds of stem variety were analysed using the χ^2 test (Fisher, 1934) and the differences shown in the table were found to be highly significant. Trees with stems of Warwickshire Drooper, Utility and Myrobolan B were highly resistant, whereas, where Denniston's Gage, Purple Egg, or Victoria was the stem a large number of cankers developed, some of which proved fatal to the trees. It should be noted that trees with Purple Egg stems had only two trees cankered until October, 1941, six years after planting, when a further thirteen trees developed stem cankers.

TABLE II.

TRIAL B. NUMBERS OF TREES (MAX. 12) CANKERED AND DEAD, FROM 1937 to 1942.

Stem variety.	Trees cankered.	Trees dead.
Yellow Egg on Yellow Egg	2	0
Yellow Egg on Myrobolan B	6	0
President on Myrobolan B	0	0
Victoria on Myrobolan B	6	2
Warwickshire Drooper on Myrobolan B	2	0

In Trial B, it will be remembered that all the trees received the most favourable spraying treatment and were pruned during the safer time. The number of cankers was not large and only two trees, on Victoria stems, died. Trees with stems of President proved significantly less susceptible than the four others, but on the number of cankers alone, it cannot be said with any certainty that Yellow Egg, either on Yellow Egg or Myrobolan B, or Warwickshire Drooper was less susceptible than Victoria. The fact that the cankers were fatal only on trees with Victoria stems indicates some measure of

resistance for the other varieties, but high mortality in similar trees of Victoria with Yellow Egg stems on Myrobolan B outside this trial leads to the belief that this stem variety's resistance is not very high.

There was no difference either in the numbers of stem cankers or of branch cankers on trees pruned in October and May.

(*b*) *Effect on growth and cropping of the trees.*

Stem-builders.—The comparative size of the tree, as shown by average height and spread, shape, the relation of the one to the other, trunk thickness and crop up to the end of 1942, seven years after planting out, are set out in Table III.

TABLE III.

GROWTH AND CROPPING OF VICTORIA ON DIFFERENT STEM-BUILDERS UP TO THE END OF 1942.

Stem-builder.	Height m.	Spread m.	Height÷Spread.	Cross section of stem (sq. cm.)	Total crop lb.
Utility	4·8	4·7	1·02	137	77
Warwickshire Drooper	4·7	4·6	1·03	131	68
Purple Egg	4·8	4·6	1·06	125	61
Denniston's Superb	4·7	4·5	1·05	126	76
Myrobolan B (unworked)	4·6	4·5	1·02	109	77
Myrobolan B (worked)	4·5	4·5	1·01	103	68
Victoria	4·5	4·5	1·00	98	78
(*Trial B.*)					
Yellow Egg on Myrobolan B	4·6	4·4	1·04	122	103
Warwickshire Drooper on Myrobolan B	4·5	4·3	1·05	130	99
Victoria on Myrobolan B	4·3	4·1	1·05	90	91
President on Myrobolan B	4·1	4·0	1·04	109	103
Yellow Egg on Yellow Egg	4·1	3·9	1·04	82	70

In Trial A the trees with the largest heads were those with Utility and Warwickshire Drooper stems. Purple Egg and Denniston's Superb stems gave trees nearly as large in the head, though rather more upright in shape. They also had considerably smaller trunks. Trees on Myrobolan B stems, both unworked and worked, were smaller in the head and definitely slighter in the trunk. These trees, owing to the early leafing-out of the Myrobolan stem feathers, received a severe check when they were planted out, owing to the rather late planting. They were checked further when the mass of feathers they produced was removed in 1938. Trees with Victoria stems were the smallest of all.

All the trees in Trial B were smaller than in Trial A, but this was probably the effect of May pruning (see Table IV). The effect of rootstock, even through the common stem-builder, Yellow Egg, was marked, the trees with Myrobolan B roots being much larger than those on Yellow Egg rootstock. The variety President used as a stem-builder has given dwarfed trees throughout and there is reason to believe that this is due to some form of incompatibility. In addition to the twelve trees in the trial, fifteen similar trees on this variety were planted on the headland as guard trees. Of the twenty-five trees, ten had yellow leaves and stunted growth and evinced every sign of incompatibility by August, 1943. This is surprising, since in a previous rootstock trial the combination of President and Myrobolan B gave immense trees (Hatton, 1936) and there was no suspicion of any incompatibility between rootstock and scion. As the only new factor is the imposition of a second scion, Victoria, on the President stem, the behaviour of these trees evidently needs further investigation.

In Trial A the differences in cropping between the different kinds of tree were not large. Trees with Victoria, Utility, Myrobolan B (unworked) and Denniston's Superb stems were the heaviest croppers, while those with Purple Egg stems were notably lighter. There was a very marked difference in cropping connected with position in the field, trees at the south end of the trial cropping much more heavily than those at the north. This may be partly responsible for the generally heavier crops harvested from Trial B, which is situated to the south of Trial A ; but, as will be seen, the fact that all the trees in Trial B were pruned in spring probably also contributed to this result. In this trial it was noteworthy that the trees with President stems, exhibiting the tendency to incompatibility mentioned above, cropped heavily up to 1942. At the time of writing, however, it does not appear likely that this record will be maintained. Apart from this, the crops were roughly proportional to the size of the trees.

Time of Pruning.—The differences in size, shape and cropping of the trees in Trial A, pruned in autumn and in spring, are set out in Table IV, the averages given being those for trees with all the different stem-builders.

TABLE IV.

GROWTH AND CROPPING OF VICTORIA ON ALL STEM-BUILDERS IN TRIAL A, PRUNED IN AUTUMN AND IN SPRING UP TO THE END OF 1942.

	Trees pruned in Autumn.	Spring.
Height (m.)	4·84	4·50
Spread (m)	4·66	4·44
Height ÷ Spread	1·04	1·01
Cross Section of Stem (sq. cm.) ..	124	113
Total Crop (lb.)	66	78

There are clear differences in the vigour, habit of growth and crop between the trees pruned in the two seasons. Those pruned at the normal time made vigorous upright growth and made considerably larger trees than those pruned in May. The effect of the May pruning was to encourage the formation of numerous lateral growths giving a smaller, more compact and denser head. The spring pruned trees also cropped more heavily than those pruned in autumn. The means shown in Table IV, being based on 126 trees in each instance, show highly significant differences.

Attempts to control the disease by spraying.

As indicated in the introductory paragraphs to this paper, Wormald (1931) suggested two spraying measures by means of which it might be possible to control the disease. Although their inclusion would rather complicate the trials, it was resolved to embody them in the same experiments as the measures described above for three reasons. (*a*) It should be emphasized that these trials were essentially exploratory, and it seemed desirable at the time to try to obtain a maximum amount of information with a minimum expenditure of land and trees. (*b*) There were at the time many hundreds of acres planted with Victoria plum trees in which the occurrence of Bacterial Canker was a serious problem. It was thus necessary to find some means of controlling the disease in established plantations. (*c*) If the pomological methods of control should prove a failure or uneconomic in practice, then there would be no alternative means of control, except by spraying. It was therefore decided to superimpose on Trial A treatments designed to test the two possible means of control (i) spraying the trunk and crotch with a bactericide in October, when it was believed infection was most likely to take place, (ii) spraying the foliage during the spring and summer months to control the leaf-spot stage of the disease.

Design of experiment.

The generous replication of the trees with different stem-builders lent itself fairly readily to this design, though it would have been easier to carry out had it been possible to include guard trees around differently sprayed plots. It will be remembered that the trial consisted of nine blocks each containing four trees with each stem-builder variety, two of which were pruned in autumn and two in spring. It was then thought that stem cankers were most likely to occur while the trees were still young, at which time it would be quite possible by the use of screens to spray the trunk and crotch without serious drift from one tree to another. Accordingly, of the fourteen pairs of trees in each block, one of each pair was selected at random for stem spraying in autumn, while the other was to be left unsprayed.

In spraying the foliage in summer, drift was much more difficult to prevent and, as guard rows could not be included, it was essential to use large blocks of trees to minimize its effect. Three treatments were decided upon, (i) unsprayed, (ii) sprayed once, and (iii) sprayed twice. The nine blocks of 28 trees each were then used to form a 3 × 3 latin square, giving three replications of each of the three treatments.

Details of spraying measures used.—The sprays were applied from a hand-operated "Cascade" machine in the first year, and after that from suitable power-spraying machinery working at 300-400 lb. pressure. Large canvas screens were used as necessary to check spray drift, but they were only moderately effective as the trees got larger.

(*i*) *Stem spraying in autumn.*—In 1936, Bordeaux mixture at 10:15:100 was applied on 30th November. This was considered to be rather late, and in the three subsequent years, 1937-39, the spray was applied about the third week of October. From 1940, when the trees had grown too large to permit the spraying of single trees without extensive spray-drift, the autumn spraying was discontinued.

(*ii*) *Foliage spraying in spring and summer.*—During 1937-39, the foliage sprays were applied at petal fall (usually about the end of April) and three weeks later on the twice-sprayed plots, and at

petal fall alone on those once sprayed. In 1937, Bordeaux mixture (6 : 9 : 100) was used, but caused damage to the leaves as small necrotic spots. Both Bordeaux sprays in 1938 and 1939, therefore, were of 4 : 6 : 100.

In 1940 the spring spray treatments were modified in the light of experience gained in the preceding years. The petal fall spray, which had shown no appreciable effect on leaf-spot, was omitted, and the first spray (Bordeaux mixture, 6 : 9 : 100, plus a wetting agent) was applied soon after bud-burst. The second spray (Bordeaux mixture, 4 : 6 : 100) was applied about three weeks after petal fall to the twice-sprayed plots only. In 1940, cotton seed oil (0·75%) was added to this spray to obviate the risk of damage to the foliage, but it was unobtainable the next year. In 1941, bad weather delayed the application of the second spray by about ten days.

In 1942, the bud-burst spray was omitted as it had given no result, and the once-sprayed plots were sprayed with Bordeaux mixture 4 : 6 : 100 three weeks after petal fall, a period already found to be crucial. The twice-sprayed plots received in addition a " colloidal " copper preparation at 0·025% metallic copper about six weeks after petal fall. This preparation was used to avoid the unsightly deposit left on the fruit by Bordeaux mixture when applied at this period. The details are summarized in Table V.

TABLE V.

TIME AND CONCENTRATION OF SPRAYS USED IN DIFFERENT YEARS.

Year.	(a) Autumn.	(b) Budburst.	(c) Petal fall.	(d) 3 weeks after (c).	6 weeks after (c).
1936	[1]B.M. 10/15				
1937	B.M. 10/15		B.M. 6/9	B.M. 6/9	
1938	B.M. 10/15		B.M. 4/6	B.M. 4/6	
1939	B.M. 10/15		B.M. 4/6	B.M. 4/6	
1940		B.M. 6/9 + wetter		B.M. 4/6 + [2]C.S.O.	
1941		B.M. 6/9 + wetter		B.M. 4/6	
1942				B.M. 4/6	[3]C.C. 0·025% Cu.

[1] Bordeaux mixture—Bluestone/Hydrated Lime per 100 gallons water.
[2] Cotton Seed Oil (0·75%).
[3] Colloidal Copper (0·025% metallic Copper).

Results.

The records made on the trees have already been detailed. The results of the spraying treatments have been rather disappointing, largely owing to the success of the method of raising the trees with resistant stems. There were thus comparatively few susceptible trees upon which to make comparisons of spraying.

Stem Cankers.—Considering susceptible stems only, there was no effect on cankers of stem spraying and only a suggestion that two foliage sprays were having some effect ; this (see Table VI) did not reach the level of significance (P = 0·05) as shown by the χ^2 test.

TABLE VI.

EFFECT OF FOLIAGE SPRAYS ON NUMBER OF STEM CANKERS.

Foliage sprays.	Trees cankered.	Trees not cankered.	Total trees.
0	16	20	36
1	22	14	36
2	12	24	36
	50	58	108

$\chi^2 = 5·66$. P. a little more than 0·05.

Branch Cankers.—In autumn, 1941, some 16 per cent. of the trees developed branch cankers, and an analysis of the data obtained showed that there were significantly less trees affected where the foliage had been sprayed twice, as shown in Table VII, and that neither of the other treatments had had a similar effect.

TABLE VII.

EFFECT OF FOLIAGE SPRAYS ON NUMBER OF TREES WITH BRANCH CANKERS IN 1941.

Foliage sprays.	Trees with cankers.	Trees without cankers.	Total trees.
0	17	62	79
1	17	66	83
2	5	77	82
	39	205	244

Shot-hole.—The foliage sprays had a marked effect in reducing the amount of shot-hole, as shown by the numbers of trees only slightly and severely affected, in Table VIII. In 1938, the reduction was

TABLE VIII.

NUMBER OF TREES SHOWING SLIGHT AND SEVERE SHOT-HOLE IN 1938 AND 1939.

Severity of Disease.	Number of Foliage Sprays 1938.				Number of Foliage Sprays 1939.			
	0	1	2	Total.	0	1	2	Total.
None or Slight ..	58	59	80	197	24	55	72	151
Severe	22	24	3	49	56	28	11	95
Total	80	83	83	246	80	83	83	246
	$\chi^2 = 20{\cdot}92$ $P < {\cdot}01$.				$\chi^2 = 56{\cdot}61$ $P < {\cdot}01$.			

confined to the trees sprayed twice, but in the following season with a generally higher infection, the proportion of severely affected trees was less even on the single sprayed plots and much less on those sprayed twice. This effect, though quite clear, was rather difficult to establish, owing to the high variation on the unsprayed plots. Thus, in 1938, while the vast majority of the trees on the twice-sprayed plots were only very slightly affected, on the other plots the infection on individual trees varied from 0 to 100 per cent. Thus an analysis of variance on the proportions affected in each plot failed to show significant differences due to spraying, owing to the small number of replications. But the highly significant result shown by the χ^2 test leaves little doubt that the effect was in fact a real one.

Plum Rust.—In 1938 a record, made on 9th September, showed that two foliage sprays had significantly reduced the incidence of Plum Rust (Table IX).

TABLE IX.

AVERAGE SUM OF CATEGORIES FOR RUST PER PLOT.

Foliage sprays.	Average per plot.
0	56·0
1	54·3
2	44·5
	Significant Difference = 3·9.

Detailed records were not made in subsequent years, but observations confirmed the effectiveness of foliage sprays, particularly those made at the end of May or in June. No other treatment showed any influence on Rust.

Defoliation.—Records were made during October in 1938, 1941 and 1942. In each year there was a tendency for trees sprayed during the early summer to retain their leaves longer than those sprayed at or before petal fall or than those left unsprayed, in spite of some defoliation by sprays. In 1942 the difference reached significance as shown in Table X.

No other treatment showed any influence on defoliation.

Spray Damage.—Bordeaux mixture (6:9:100), though safe pre-blossom, proved unsafe afterwards since it caused severe burning of the leaves in small, irregular, scattered spots, at first yellowish, then brown. The spots finally dropped out to give a "shot-hole" effect. The bacterial infections by

comparison are more regular in shape and size, being roughly circular and, in the early stages, surrounded by a distinct and characteristic pale halo. They, too, are brown in the later stages, and the centres ultimately drop out as on spray-damaged leaves.

TABLE X.

Foliage sprays.	Defoliation Index (Max. 5·00).
0	5·00
1	2·75
2	2·61

(Insignificant difference shown by brackets.)

At 4 : 6 : 100, Bordeaux applied post-blossom caused little damage, except when spraying was followed by a wet period. The colloidal copper preparation, used at 0·05% metallic copper on an adjoining plot in 1941 and followed by wet weather, caused so much leaf burn and leaf drop that the strength was halved for use on the trial plot in 1942. Here there was no appreciable damage. On the one occasion (in 1940) on which it was used, cotton-seed oil Bordeaux proved safe.

Discussion.—The outstanding result of these trials was the success of the method of using a resistant variety to form a stem and crotch upon which to graft the susceptible Victoria. Out of seven varieties tried, four gave a high degree of resistance to the disease. Whether or not this resistance will be maintained remains to be proved, for the sudden breakdown of the apparently highly resistant stem-builder variety Purple Egg at a comparatively late stage in the experiment must not be forgotten. It is of course possible that the imposition of the highly susceptible Victoria may have contributed to the breakdown in the resistance of the stem-builder variety. Of the four resistant varieties used as stem-builders for Victoria, President must be regarded as unsuitable at any rate upon Myrobolan B rootstock, because of the apparent incompatibility. From the commercial point of view the promising variety is Myrobolan B, because the stem can be run up upon its own roots and the tree thus be produced more cheaply. Warwickshire Drooper might possibly be of value and propagates well on its own roots, but little is known of its performance as a rootstock.

The lack of result from the differential pruning treatment is interesting when considered in the light of inoculation experiments, where the autumn wounds were the more readily infected (Wormald, 1931). These pruning treatments were applied only to the branches, however, and, since plum branches are not often attacked, they are possibly less susceptible in general than the stem, so that wounds made in them would be the less likely to become infected.

The autumn stem spraying upon individual trees was found more difficult to carry out in practice than had been originally anticipated, owing to the difficulty of preventing drift. It had therefore to be discontinued after four years. Nevertheless, there was no evidence of any control by this means during this period. This is in marked contrast to the success of a similar autumn spray on cherries (Montgomery and Moore, 1938). It may be that the best time for application is different in plums and cherries, a possibility which is being further investigated.

In spite of high variation in the distribution of leaf-spot there is little doubt that the spring and summer foliage sprays materially reduced infection. The importance, however, of controlling the leaf-spot phase has yet to be proved. In this trial, cankers were only slightly less numerous where leaf-spot was controlled year after year than where it was not. Perhaps nothing but perfect control of leaf-spot is good enough to ensure against Canker in the absence of effective autumn spraying of the stems, for a very few leaf-spots under suitable weather conditions could liberate millions of living bacteria. The value of these foliage sprays, however, does not depend entirely on prevention of stem cankers since they have shown a marked effect on branch cankers and the general health of the trees. This latter point is borne out by the data on defoliation, especially those obtained in 1942, when two foliage sprays resulted in longer retention of leaves in October. Although the large majority of the fallen leaves on unsprayed blocks had prematurely dropped owing to attack by Rust, many appeared to be quite free from disease.

The following tentative recommendations are offered :

1. The use of resistant varieties, such as Myrobolan B or Warwickshire Drooper, to form a framework for valuable susceptible ones. In this connection, the technique of framework grafting is worth exploration.

2. The application of Bordeaux mixture (4 : 6 : 100) about three weeks after petal fall (i.e. spray usually about the third week of May), and of a colloidal copper preparation diluted to contain approximately 0·025% metallic copper, about six weeks after petal fall.

Acknowledgements.—These trials, like many others at the Station, have been undertaken and carried out by a number of workers, and it has fallen to the lot of those whose names appear at the head of this paper to give an account of them. Dr. R. G. Hatton, Dr. H Wormald and Mr. J. Amos all collaborated in the initiation and design of the experiments, while Mr. R. J. Garner was responsible for raising the trees. In addition, numerous members of the Station's Recording Staff have helped to obtain the various measurements of tree size and crop that have been made. The authors gratefully record their indebtedness to all these among their fellow workers.

Summary.—The results of two exploratory trials designed for the prevention and control of Bacterial Canker, caused by *Pseudomonas mors-prunorum* Worm., in Victoria plum trees are described. The trials included measures designed to control the disease by building up a tree that would be resistant and by the avoidance of pruning wounds at the time of year, October to December, at which infection was most likely to occur. Should these be unsuccessful, and to find a means of control in established plantations, methods of spraying with a bactericide were also included. The use of the varieties Myrobolan B, Warwickshire Drooper, Utility and President, themselves resistant, to form the stem and crotch of trees upon which to graft the susceptible Victoria, was highly successful in preventing the occurrence of stem cankers. There were, however, no fewer cankers on trees branch-pruned during the summer period, during which artificial inoculations had failed, than on trees pruned in the more dangerous autumn months. Differences were observed in the vigour and cropping of trees of Victoria with different varieties as stems all on Myrobolan B rootstock ; while in one instance, Victoria on President stems on Myrobolan B rootstock, the combination of the three appeared to be incompatible. Trees pruned in the spring were smaller and cropped more heavily than those pruned in autumn.

Spraying the stems and crotch of the trees with Bordeaux mixture 10 : 15 : 100 in October during the first four years after planting was ineffective in controlling the disease. However, foliage sprays of Bordeaux mixture 4 : 6 : 100, particularly those applied three weeks after petal fall and later, appreciably controlled the so-called " shot-hole " stage of the disease and reduced the number of branch cankers. This method of control did not, however, appreciably reduce the number of stem cankers.

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BACTERIAL DISEASES OF ACID CHERRY TREES

By H. WORMALD

Not only sweet cherries but acid cherries also, particularly Morellos, are subject to bacterial diseases. The most common signs of bacterial attack are spots on the leaves. Sometimes the spots are numerous and then they are very small and angular. When they are fewer they are larger and less angular, sometimes almost circular and up to one-eighth of an inch in diameter. They are dark brown but the larger spots are usually surrounded by a pale green or yellow zone of tissue ("halo"), which gradually merges into the general green of the rest of the leaf. When the spots are fairly numerous the leaves may curl up at the edges or there is some distortion of the leaf-blade. If a leaf spot is cut out and torn across with needles in a drop of water under the microscope dense masses of bacteria may be seen to ooze out from the torn edges.

In years when leaf spotting is severe it is usually accompanied by Bacterial Blossom Blight ; the flower trusses turn brown, almost black, and wither. When the flowers are killed the infection may extend into the twigs and all the leaves and flowers above the point of invasion by the bacteria then wither (Twig Blight). This condition closely resembles Blossom Wilt and Twig Blight caused by the Brown Rot fungus, *Sclerotinia laxa*, which also infects the flowers and kills the twigs. If the flowers bear *Monilia cinerea*, the conidial stage of *S. laxa*, the disease can be assumed to be caused by the fungus. If, however, the withered flowers show no trace of Monilia, particularly in wet weather,

and if the withering is accompanied by severe leaf spotting the disease is probably bacterial, but microscopical and cultural tests are necessary for exact diagnosis. Late frosts too may cause a withering of the flowers resembling bacterial blossom blight.

Further infection may occur as the fruit develops. Portions of the fruit stalks turn brown or black, and the development of the fruit is checked.

The fruit itself may also become infected, when dark, almost black, sunken spots appear at the side or at the lower end. A brown discoloration of many Morello fruits may be observed in some years, but this is probably due to bruising the skin when the fruit rubs against other parts of the tree in high winds. Many fruits showing injury of this kind have been examined but no bacteria or other infectious organisms have been found in the discoloured tissues. The darker infection spots on the other hand, contain dense masses of bacteria.

The most serious form of infection occurs when the branches or stems are attacked for then the main limbs or whole trees are affected, and, if girdled, die within a year. The lesions on branches and stems correspond to bacterial cankers in sweet cherries and in plums.

These diseases have been studied on the Morello cherry particularly, but other acid cherries are susceptible to some of them ; leaf spots have been found on Flemish Red and Kentish Red cherries, leaf spots and blossom blight on the Carnation variety.

The symptoms mentioned do not necessarily all occur together or in one season. Leaf spotting is seen nearly every year on the Morellos at East Malling, but in some years it is so slight as to be hardly noticeable. The blossom blight has been seen in a few years when the weather conditions in spring favoured the bacteria ; infection of the fruit was found in two seasons, lesions on the fruit stalks only in one year (1939).

The infected tissues contain numerous bacteria, and the organisms can be isolated without difficulty, except from lesions on stems and branches, for, as in sweet cherries and plums, the organisms in such tissues tend to die out during the summer as the external symptoms—weak development and yellowing of the foliage—become noticeable.

Culture plates prepared from lesions on the various organs mentioned gave rise to one or the other of two kinds of bacterial colonies which at present may be referred to as the *A* and *B* forms. Both have been isolated from flower spurs, leaves, fruit stalks and fruit, *A* from branches and once from a stem. The *A* organism resembles, and is probably identical with, *Pseudomonas mors-prunorum*, a cause of Bacterial Canker in plums and sweet cherries. When grown on nutrient agar with cane-sugar the *B* colonies have a structure different from those of *A*, and the two can be readily distinguished under a low power of a microscope. Inoculation experiments have shown that both are pathogenic. When sprayed on to Morello foliage each of them gives rise to leaf spots ; they readily infect green Morello fruits when these are inoculated through punctures, and Morello branches have been killed by inoculating them with the *A* form. Blossom Blight has not yet been induced by artificial inoculation ; this disease apparently needs conditions very favourable for the organism.

Little is known about the distribution of these diseases on acid cherries in Britain. Up to the present they have been noticed only in Kent—at East Malling, Crockenhill (blossom blight and leaf spot), and Maidstone (leaf spot only). Growers who have acid cherries showing any of the symptoms described are asked to send specimens to this Station for examination.

Summary.—Diseases on acid cherry trees caused by bacteria are briefly described. Two organisms, distinguishable by their cultural characters, have been isolated from leaf spots, wilted blossoms, fruit, and fruit stalks. One of them infects the branches and stems also.

A PHYTOPHTHORA DISEASE OF THE HOP IN GREAT BRITAIN*

By W. G. KEYWORTH

In September, 1942, the writer noted a disease, previously unrecorded on hops in Great Britain, attacking the variety " Brewer's Gold " on three separate farms in the south-eastern hop-growing area.

The first noticeable symptom is a yellowing of the leaves on one or more bines of the hill. The leaves and laterals then wilt but the bine at first remains green and firmly attached to the rootstock. The wilted leaves soon die and blacken but remain attached to the bines which eventually themselves become blackened and dead.

On cutting the roots and rootstocks the vascular tissue is found to be discoloured. In some of

* Reprinted, by kind permission, from the *Gardeners' Chronicle*, CXIII, June 12, 1943, p. 238.

the roots the whole of the wood cylinder is a dark brown colour, somewhat resembling strawberry roots affected with Red Core disease (*Phytophthora Fragariae* Hick.). The discoloration can be traced from the roots into the stock, affecting all or part of the woody tissue and sometimes extending up to twelve inches inside the bines where the wood is dark brown, flecked with darker streaks (see Plate I). The disease can thus be distinguished from Verticillium Wilt (Keyworth, 1942) where the wood cylinder is a homogeneous light brown colour which commonly extends for the whole length of the bine. In addition to the brown wood, in plants affected with *Phytophthora*, dark brown or black water-soaked patches are often present in the cortex of the roots, stock, and bases of the bines and may completely girdle the affected parts.

Sections of the discoloured wood show that the vessels are choked with fungal hyphae and tyloses. Isolations from the infected wood in the bines, stock and roots, and also from the rotted cortical areas have consistently yielded a species of *Phytophthora* which resembles *P. Cactorum* (Leb. and Cohn) Schroet., but which has not yet been finally identified. Preliminary inoculations with this fungus into the basal ends of hop cuttings have produced the typical brown discoloration of the wood and the fungus has been re-isolated from the wood at distances up to two inches from the point of inoculation. There seems little doubt, therefore, that the fungus is the cause of the disease.

The disease has at present been seen in three localities only in Great Britain, viz. near Brenchley and at Cranbrook in Kent, and in Sussex near Hawkhurst. On one farm it affected eighty-seven out of one thousand plants and on another farm about thirty to forty plants were diseased. The affected plants were in groups and the infection appeared to be spreading from one or more foci.

The disease resembles that described as Black Root-Rot of Hops in New Zealand by Brien (1938) but Brien does not refer to the discoloration of the vascular tissues, one of the most striking features of this disease in England. In view, however, of the other similarities in symptoms and the fact that the New Zealand disease is caused by a strain of *Phytophthora Cactorum* it is probable that the two diseases are identical.

Work is now in progress to determine the identity and pathogenicity of the *Phytophthora* sp. isolated from the infected plants and also to investigate the susceptibility of the other hop varieties. In view of the fact that, in New Zealand, Black Root-Rot is reported to be very serious in areas where wet soil conditions prevail, a study will be made of the effect of such conditions on the disease in Great Britain. In the meantime, in view of the possible serious consequences of the spread of this disease, growers who suspect an outbreak are asked to communicate with the East Malling Research Station.

Fig. 1.
Phytophthora Disease of Hops.

Summary.—A disease new to hops in Great Britain and discovered on three farms in September, 1942, is briefly described. It is chiefly characterized by a wilting and death of the bines, accompanied by a rotting of the cortical tissues and a brown discoloration of the wood of the roots, stock, and bases of the bines. It appears to be caused by a species of the fungus *Phytophthora* resembling *P. Cactorum*.

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ENTOMOLOGY

NOTES ON SOME INTERESTING INSECTS OBSERVED IN 1942

By A. M. MASSEE

1. Apple Fruit Rhynchites (*Rhynchites aequatus* L.). Very early infestations of the Apple Fruit Rhynchites occurred in several apple plantations in the Bekesbourne district in the spring. It is usual for the weevil to make its appearance in the orchards about petal fall, but the attacks noted in the Bekesbourne district were very much earlier, and the weevils were seen feeding on the buds, that were still in the green-cluster stage. The feeding was considerable and continued during the pink-bud stage, and even the fully opened flowers were attacked and the petals damaged.

In several orchards the infestation was considered bad enough to warrant the application of a derris dust. The dust was applied at the pink-bud stage, and prevented further injury to the blossoms.

2. Apple Blossom Weevil (*Anthonomus pomorum* (L.) Curt.). The Apple Blossom Weevil has been very prevalent in Kentish apple orchards during the past two seasons, and hundreds of enquiries have been made about it. It can be regarded as one of the most important apple pests in Kent at the present time.

The weevil was very abundant in 1921 and 1922, and again in 1931 and 1932, and the fact that it has been very destructive during the past two seasons seems to suggest that it reaches its peak approximately every ten years.

Cordons and low bush apples are chiefly affected, but standard trees are also subject to attack. Lane's Prince Albert and Laxton's Superb are very susceptible varieties, while Bramley's Seedling is less liable to attack.

3. Clay Coloured Weevil (*Otiorrhynchus singularis* L.). A bad attack of Clay Coloured Weevil was noted in a garden of young hop sets at Ditton in May. The grub and adult stages of the weevil were present in the soil around the hop sets, and both were causing considerable damage. The grubs were feeding on the roots and the adult weevils were nibbling off the shoots, many of which had attained a height of two feet. The infestation became very severe by the third week of May, all the new growths of many of the plants being cut off.

Attempts to control the infestation by means of derris and lead arsenate dusts, combined with regular cultivation, proved successful and the plants grew away without further injury.

The infestation may be accounted for by the fact that the hop sets were planted in recently cultivated orchard pasture in which the weevils had been breeding in profusion.

4. Watercress Beetle (*Phaedon tumidulus* Gm.).—A number of enquiries were made by villagers of East Malling and Larkfield concerning the destruction of carrots growing in their gardens by some unknown pest during the first and second weeks of August.

An examination of the plants showed that they were being eaten by the Watercress Beetle and its grubs. In one garden at Bradbourne the destruction was very severe, all the foliage being destroyed. In this instance the beetles had deserted the carrot bed and moved to some celery growing close by, and started feeding on the foliage.

The headquarters of the beetle in the district is the common watercress (*Nasturtium officinale* Br.) which grows commonly in the stream which runs through both villages. Incidentally all the outbreaks reported occurred within fifty yards or so of the stream.

5. Raspberry Moth (*Lampronia rubiella* Bjerk.). The raspberry moth is not usually considered an important pest in Kent, but it can generally be found in most raspberry fields and gardens if a detailed search is made. In the past two seasons it has become much more common in the Malling district, and several enquiries have been received about it. It was also noted attacking some raspberry seedlings at the Research Station.

Young shoots examined during the third week of May were found to be withered or dead, the insides of the shoots being tunnelled and eaten away. The red grub which feeds on the pith inside the shoots was present, as well as a number of chrysalids.

The raspberry moth is a pest very difficult to control, and no reliable spray or dust has yet been found. One drastic remedy is completely successful, however. If the infestation is sufficiently severe to warrant cutting down and burning all the canes in May, a complete control will be attained, but one year's crop will be lost in the process.

6. Common Marbled Carpet (*Cidaria truncata* Hüfn.). The looper caterpillars of the Common Marbled Carpet Moth were noted in numbers feeding on the foliage of cultivated strawberry at Wisbech during the second week of May. The same species was also noted at Warsash, Hampshire,

and at Evesham, Worcestershire, a few days previously. The natural host plants of the caterpillar are wild strawberry, birch, hawthorn, etc., thus its presence on cultivated strawberry is not surprising.

The fully grown caterpillar is about an inch long, slender, wrinkled and greenish-yellow, with a number of white or yellow warts, each bearing a small hair. It has three lines along the back, the central one dark green, the others greenish-yellow, and sometimes reddish stripes or purple dashes along each side. The thirteenth segment has a rosy pointed process. There are two or more generations in a season, and the insect hibernates as a caterpillar.

This insect is not considered a pest of strawberry, but it is readily detected on the foliage and seems worth while recording.

7. Coxcomb Prominent (*Lophopteryx camelina* L.). A large number of Lepidopterous larvae feed on apple foliage, and the grower is constantly finding caterpillars which are unknown to him. The caterpillar of the Coxcomb Prominent comes within this category, and it was much more common than usual in September and October, when a number of specimens were sent in for determination.

The caterpillar is green with a dark line on the back, and a yellow one on the sides, the twelfth segment with two red tubercular projections.

The caterpillar is usually noticed on cordons and small bush trees; it probably occurs, but overlooked, on larger trees as well. It passes the winter in the chrysalis stage, and the moth is on the wing in May and June. It has a large variety of natural food plants including birch, oak, sallow, hazel and beech.

It is not considered common enough in the orchard to cause any harm.

8. Northern Drab (*Taeniocampa opima* Hüfn.). Considerable injury was caused to the tips of young shoots of loganberries on one of the plots at the Research Station in the latter part of May and early June. The damage was very similar to that caused by the Red Bud Borer. The tips of the shoots were eaten away, and the shoots went " blind ".

The caterpillar of the Northern Drab Moth, which was responsible for the damage, is dull olive green to red-brown, with darker markings, and inclining to yellowish on the underside. There are three pale lines along the back, and a yellowish stripe along the sides. The head is green.

The natural host plants are said to include rose and birch.

This is the first occasion the Northern Drab caterpillar has been noted feeding on loganberry shoots in this district, and the injury caused to the plants was serious enough to warrant picking the larvae by hand, an operation which must be carried out directly the first sign of damage is noticed, if it is to be successful.

9. Apple Leaf Skeletonizer (*Anthophila pariana* Clerck). The Apple Leaf Skeletonizer was referred to in these notes in the Annual Reports for 1932 and 1937; thus it would appear that the insect comes into prominence every few years, for in 1942 it proved to be very prevalent in the Canterbury district in May and June. Bekesbourne, near Canterbury, appears to be the headquarters of this insect on fruit, and severe outbreaks are reported from that district every few years.

The small caterpillars feed on the surface of the foliage, mainly on the upper side, and skeletonize little patches here and there. Later on many of the leaves become drawn together by silken threads. The caterpillar responsible for this characteristic form of damage is yellowish-green with a yellow line down its back. The body is dotted with black spots and the head is clear brown. When fully fed it is half an inch long.

There are two broods in a season, the second generation appearing in July and early August.

Fortunately this insect can be controlled quite readily by a thorough application of lead arsenate after petal fall.

10. Caterpillars of the Winter Moth Group –The caterpillars of the Winter Moth group are some of the most important pests the fruit-grower has to contend with, especially on farms where the spraying machinery is inadequate.

During the course of survey and advisory work in the spring months it is quite usual to find considerable patches of fruit which have been ruined by the ravages of caterpillars of the Winter Moth group. Apple, pear, plum, cherry, and nut are mostly infested, but many of the soft fruits suffer also.

Now that spraying contractors equipped with powerful spraying machines are available all over Kent, it is hoped that the devastation caused by these insects will be gradually reduced to a minimum. To achieve this it is essential to apply an arsenical spray in the green-cluster stage, while the caterpillars are still quite small, and before they eat their way right into the hearts of the blossom trusses. Very frequently the arsenical spray is applied too late in the season to effect adequate control and much valuable time and labour is wasted. For example the spraying of cherries is often delayed until after the blossom period, and by this time much of the damage has been caused. It should be mentioned also that directly the tiny fruitlets begin to grow they are attacked by the caterpillars in preference to the foliage, and considerable injury may be caused in a very few days.

It is considered that the failure of many cobnut plats to crop is largely due to the ravages of caterpillars of the Winter Moth group and of the nut weevil; it is essential, therefore, to spray the bushes thoroughly before the caterpillars destroy the crop.

In very badly neglected orchards it may be necessary to apply lead arsenate a second time, in the pink bud stage or immediately after petal fall, but it cannot be emphasized too strongly that the green-cluster application is the all important one.

11. Leaf Cutting Bee (*Megachile* sp.).—A number of nests made by a species of leaf-cutting bee were found in some hollow shoots which had been removed from a partially decayed plum tree growing in an orchard at Barming.

Some species of leaf-cutting bees frequently build their nests in the hollow stems of decayed trees. The cells are constructed entirely of leaves (in this case plum foliage), are thimble shaped, and are fitted with a lid. Each cell is partially filled with pollen and nectar, and an egg is deposited in it.

The adult bees began to emerge on 23rd May from the nests sent to East Malling. The leaf-cutting bee very much resembles the hive bee but it has a broader head and it is more robust.

The leaf-cutting bees frequently make their nests in the hollowed stems of fruit trees, but they do not cause any harm.

It is a very interesting spectacle to watch the bees cutting the leaves from the shoots and carrying them away for the purpose of building their nests.

12. Plum Sawfly (*Hoplocampa flava* L.).—The plum sawfly is very prevalent in some seasons, and certain varieties, e.g. Czar, are subject to severe attacks. The adult sawfly usually makes its appearance when Czar is in flower and in such circumstances usually confines its attention to this variety.

In 1942, however, adult sawflies were caught whilst on the wing in a plum orchard at Southfleet on 23rd April. They were noted laying their eggs in the fully opened flowers of several early flowering varieties, but they paid no attention to Czar which was not yet in full bloom. Fortunately, the attack in the orchard at Southfleet was of little consequence, on account of the heavy crop, but in an off year the story might have been very different.

Plum sawfly was noted in several districts of Kent, and it would appear to be more common than usual. Although many growers are quite familiar with the apple sawfly and the damage it causes in the early stages of an infestation, the same cannot be said of the plum sawfly, and doubtless much damage is caused by this insect without the grower being aware of the pest concerned.

The plum sawfly lays its eggs in the fully opened flowers, and the hole made in the fruitlet by the newly emerged caterpillar is easily seen with the naked eye. One caterpillar may enter as many as four fruits before it is mature.

13. Frog Hopper (*Tomaspis sanguinea* Geoff.).—The damage caused to pear fruits and apple foliage by the adults of the red and black frog hopper has been referred to in these notes in the Annual Report of 1940.

This conspicuous frog hopper feeds on a large variety of plants in addition to apple and pear, and some interesting observations were made in a cherry orchard at East Malling during the third week of June. The adult frog hoppers were feeding on the cherry foliage and were causing the typical angular brown markings on the upper surface, and sunken brown areas on the leaf stalks. They were also feeding on the fruits, making very characteristic markings. The frog hopper pierces the skin of the fruit with its proboscis, and a small drop of liquid oozes out through the puncture. Soon afterwards the area round the puncture turns black, and a little later still an area about a sixth of an inch in diameter, but irregular, becomes brown and sunken. The whole process is completed in about twenty minutes. Frequently four or five sunken areas are present on a single fruit. Injury of this nature on cherry fruits has been noticed for many years, but the cause of the trouble was not known until these observations were made.

Some interesting observations were made on the same species of frog hoppers in a hop garden at Beltring, near Paddock Wood in May. Adult frog hoppers occurred in profusion on dock and many other wild plants growing on the headlands of the garden. The frog hoppers which have strongly developed powers of jumping were also present on the hop hills in considerable numbers. They were making their characteristic brown angular markings on the upper surface of the foliage. The markings were much more plentiful on the plants of the headland row, but feeding punctures and markings were not uncommon eight rows away from the headland.

The frog hopper did not appear to injure the hops in any way or retard the growth.

14. Lacewing Bug (*Piesma capitata* Wolff).—This delicate straw-coloured lacewing bug is about one-tenth of an inch in length, and is generally distributed throughout the British Isles. It usually lives in grassy situations, and is best caught by a sweeping net.

It is therefore of interest to record it feeding on the foliage of apple in June at Cobham, East Malling, and Marden, Kent. The adults were the only stage present on apple, and a search for the

immature forms at the roots of grass and by sweeping proved unsuccessful. A number were kept in a glass-topped tin in the laboratory, and they readily fed on apple foliage provided it was fresh.

It is not an economic species but its presence on apple is noteworthy.

15. Mealy Plum Aphid (*Hyalopterus arundinis* F.). -The Mealy Plum Aphid has not been a serious pest of plum since the advent of the tar distillate wash ; it is therefore of interest to record two outbreaks in June, one in a plum orchard at Ditton and the other at East Malling.

The aphid is a very distinct species and can be recognized at once by its mealy covering. In both outbreaks the infestation was most severe on the variety Oullins Golden Gage, although other varieties were infected also. The attack was worst at the end of June. Both orchards had received a 5 per cent. tar distillate wash in December ; it is difficult, therefore, to account for the infestation, unless the aphides migrated from some unsprayed plums in the neighbourhood.

The infestations gradually diminished early in July when most of the aphides migrate to water-grasses and weeds. They return to plum in the autumn and deposit their eggs on the spurs.

16. Potato Aphid (*Macrosiphum gei* Koch).—The potato aphid feeds on a large number of plants including strawberry, but the latter plant cannot be regarded as a favourite host.

During the past two seasons the strawberry aphid (*Capitophorus fragariae* Theob.) has been very scarce in Kent, and in the course of routine surveys of strawberry fields in different parts of Kent the potato aphid has been noted more frequently than the recognized strawberry species. The potato aphid occurs mainly on the under surfaces of the older leaves and the leaf stalks, but it is never present in large numbers. It occurs sparingly in the winter months also.

The occurrence of the potato aphid on cultivated strawberry appears to be general since it was found in every field during the course of a survey of a large number of strawberry fields in Kent, Hampshire, Worcestershire and Cambridgeshire in June.

The potato aphid is not regarded as an economic species on strawberry since it is never very numerous and it is not a vector of Yellow-edge or of Crinkle.

17. Common Earwig (*Forficula auricularia* L.).—A very severe attack of the common earwig in hops was reported from the Rochester district in June.

The earwigs were present in tens of thousands in a pole-work garden, where they sheltered in daytime under clods of earth and in cracks in the poles. They came out at night and fed on the tender foliage, which as it grew out, assumed a stunted and ragged appearance. The attack continued for several days, and attempts to check it by means of derris dusts and nicotine sprays proved unsuccessful. A thorough spraying with a lead arsenate spray, applied by means of a hop washing machine proved effective in checking the earwigs, for the infestation gradually dwindled and the damage ceased.

18. Currant Eelworm (*Aphelenchoides ribes* (Taylor) Goodey).—A very severe infestation of the currant eelworm was noted in a plantation at Brenchley at the end of April. The currant plantation consisted of five acres of Baldwin, Triple X and Daniels' September Black. Most of the bushes of Daniels' September Black, consisting of about three-quarters of an acre, were affected. Most of the buds on the young wood were dormant, particularly those near the tips of the shoots. The damage was very conspicuous at the end of April when most of the bushes would normally be in full leaf. The damage was so severe that the bushes ceased to crop entirely and the grower wisely decided to grub them.

One point of particular interest was noted in the plantation. A careful examination was made of the buds of the varieties Baldwin and Triple X but the eelworm could not be found on either of them, although some of the bushes were growing adjacent to the Daniels' September Black.

19. Fruit Tree Red Spider (*Oligonychus ulmi* Koch).—Inquiries concerning the severe attacks of the fruit tree red spider have been received from many districts of Kent and Essex. The nature of the enquiries have all been the same. The growers state that although their orchards were sprayed with a petroleum wash in the spring, the infestation of spider by the latter part of July was just as bad on the sprayed trees as on the unsprayed trees, apple and plum being chiefly affected.

The explanation is as follows. The fruit tree red spider has been very prevalent in the fruit growing areas of most districts, and it has been abundant on many kinds of trees and shrubs in addition to cultivated fruits. A general migration of adult female mites occurred in June, and many orchards previously free of mite became infested by a nucleus of mites. A large proportion of the migrating mites came from trees in the hedgerows such as hawthorn, whitethorn and elm. Weather conditions at the end of June and in July were congenial to the mites and large populations were built up by the autumn ; in many orchards the infestation was very severe and premature defoliation resulted.

20. Broad Mite (*Hemitarsonemus latus* (Banks)). –Specimens showing a bad infestation of mite were sent in from Harpenden from some potatoes growing under glass in May. The mite proved to be a species of Tarsonemus, known by the popular name of Broad Mite in America, where it is very

destructive. It attacks a wide range of plants including mango, beet, tea and various trees and shrubs. The same species was reported a few years ago at Wisley on fuchsia.

The mite breeds very quickly when the conditions are suitable, and it may cause considerable injury to the leaves and young shoots of plants.

Superficially the mite very much resembles the strawberry Tarsonemid Mite, but the egg stage is very characteristic. It is oblong-oval, the lower surface smooth and transparent and the upper surface studded with round, whitish tubercles, arranged in six longitudinal rows, with eight tubercles in the longest row.

21. Free-living Gall Mite of Plum (*Phyllocoptes fockeui* Nal.).—An unusually bad attack of *Phyllocoptes fockeui* Nal., a free-living species of gall mite, was noted on the cherry variety plot at the Research Station. The mites were confined to the under surfaces of the foliage, and were very numerous on some trees. Morello was very subject to attack, and a seedling variety also was badly affected. Plums and damsons interplanted among the cherries were infected to a lesser degree.

The mites hibernate under the scales of the buds during the winter months, and start attacking the leaves again the following April.

The mite is not visible to the naked eye, but may be seen with a hand lens with a magnification of ten times.

22. Plum Gall Mite (*Phytoptus phloeocoptes* Nal.). Enquiries concerning this interesting species of gall mite have been received from Evesham and Worcester. It cannot be considered an economic species, but its presence is readily detected because of the characteristic galls it produces on the twigs at the base of the spurs. The galls are about $\frac{1}{12}$ in. in diameter, and sometimes twenty or thirty are present at the base of a single bud. There is a marked varietal susceptibility. The variety Magnum Bonum is frequently very badly affected, while Purple Pershore and Yellow Pershore are attacked to a lesser degree. Other commercial varieties seem to be resistant to attack.

This mite was very common in plum orchards in the West of England some twenty years ago, but it is rarely seen in commercial plantations at the present time, the explanation being that it is readily controlled by the routine tar distillate wash which is applied to most commercial plum plantations.

Summary.—Notes are given on twenty-two species of insects observed on fruit in 1942.

INSECTICIDES AND FUNGICIDES

FIELD TRIALS OF PHENYL MERCURY CHLORIDE FOR THE CONTROL OF POTATO BLIGHT

By H. B. S. MONTGOMERY and H. SHAW

The copper supply situation in recent years has made it imperative that no opportunity should be overlooked of finding an effective alternative fungicide, particularly for use on potatoes. So, among other substances, the organo-mercury compounds attracted attention. At first sight the prospect is, perhaps, somewhat extravagant, but if a form of mercury could be found having a potency of at least one hundred times that of copper in Bordeaux mixture, it could compete in price with copper preparations. Laboratory tests (to be reported elsewhere) against spores of *Venturia inaequalis* had revealed the very high toxicity of several organo-mercurials and among these phenyl mercury chloride was outstanding. Another property of this substance desirable in a protective fungicide is its low solubility in water; in addition it is one of the most readily accessible members of this group and one of the least toxic to animals. For these various reasons phenyl mercury chloride was chosen for comparison with Bordeaux mixture against Potato Blight (*Phytophthora infestans*). The trials were carried out in two seasons using the variety British Queen, chosen because of its known susceptibility to Blight.

In 1941 comparison was made between no spray, a 10 : 15 : 100 Bordeaux mixture (0·25 per cent. copper), and two preparations of phenyl mercury chloride precipitated on china clay to give 0·1 per cent. and 0·2 per cent. respectively of mercurial in the dry powder. The last two were used at 0·5 per cent. giving concentrations of 0·0005 per cent. and 0·001 per cent. respectively of phenyl mercury chloride in the wash as applied. The trial comprised sixteen plots containing six rows of nine plants, each plot being surrounded by a guard row. The whole was divided into four randomized blocks each containing all four treatments, viz.: nil, Bordeaux, and two levels of the mercurial. The sets were planted on 12th May and made good growth, though there was a rather high proportion of misses. In view of prolonged drought and the absence of conditions favouring Blight, the plots were watered by overhead irrigation for sixteen hours on 8th, 9th, and 10th July to the equivalent of about two inches

of rain. The first application of sprays was made on 11th July, using a knapsack sprayer, care being taken to ensure thorough cover. The sprayings were repeated on 12th August, this time particular attention being paid to the new growth on the plants. No sign of Blight appeared until 19th August ; a week later the disease was spreading rapidly and plots sprayed with the mercurial could be distinguished from unsprayed controls only by a delay of not more than three days in the progress of defoliation. By 8th September defoliation was virtually complete on all but the copper-sprayed plots, where it was delayed by about three weeks. The crop was harvested on 7th October and the tubers graded. Close examination failed to reveal more than an insignificant amount of Blight and there was no appreciable increase after storing for two months. Although the Bordeaux-sprayed plots gave the highest mean yield (149 lb.) this was not significantly greater ($P = 0{\cdot}05$) than the yield from mercurial-sprayed at 0·001 per cent. (138 lb.) or at 0·0005 per cent. (136 lb.) or from unsprayed plots (134 lb.).

In 1942 the scope of the trial was extended to include two types of mercurial preparation : in addition to the precipitates on china clay, suspensions in sulphite lye were used. The concentration of phenyl mercury chloride was raised to 0·00125 per cent. and 0·0025 per cent. in each of the two forms and these were compared with 8 : 10 : 100 Bordeaux mixture (0·2 per cent. copper). This trial, planted on 1st May, comprised thirty-six plots of the same size as before and with guard rows round each plot. It was arranged in six randomized blocks each containing the six treatments, viz. : nil, Bordeaux, and two levels of the mercurial in each of two forms. The plants grew well and there were very few misses. The sprays were applied first on 9th July, using a power spraying machine, and were repeated on 6th August. Rain fell throughout the day following the first spraying. Blight was first seen on 21st August and the infection then appeared to be two or three days old. Again the disease spread very quickly and this time it was difficult to distinguish mercurial-sprayed plots from unsprayed. The trial was surveyed on 28th August and again on 2nd September and the intensity of disease assessed on the following scale based on that proposed by the Plant Pathology Committee of the British Mycological Society (Moore, 1943).

0·1. Only a few plants affected.
1·0. About ten spots per plant, general light spotting.
10·0. About half the leaflets spotted.
25·0. Nearly every leaflet affected.
50·0. About half of the leaf area destroyed.
75·0. About three-quarters of the leaf area destroyed.
100·0. All leaves dead.

The average category figures of the six replicates on each of the two dates were :

Date.	Nil.	0·00125% C_6H_5HgCl.		0·0025% C_6H_5HgCl.		8 : 10 : 100 Bordeaux.
		Sulphite lye.	China clay.	Sulphite lye.	China clay.	
28th August	46	27	27	29[1]	20	0·01[2]
2nd September	96	100	96	88	92	2·5

[1] Includes the only plot rated 100 on 28th August. [2] Represents a single focus of disease in one plot.

These figures indicate that the lower concentration of phenyl mercury chloride may have delayed the spread of the disease very slightly, the higher concentration possibly a little longer. Each, however, compared very unfavourably with the Bordeaux treatment. Defoliation of all but copper-sprayed plots was complete by 7th September and was not noticeably later on mercurial-sprayed plots than on unsprayed. The crop was dug on 17th November ; in view of labour difficulties and the obvious absence of appreciable differences between unsprayed and mercurial-sprayed plots, only the Bordeaux-sprayed and the unsprayed plots were hand-dug and recorded. Although the Bordeaux-sprayed plots again gave the higher mean yield, 165 lb. against 154 lb., the difference was not significant ($P = 0{\cdot}05$). The amount of Blight seen on the tubers was negligible.

These two trials show that phenyl mercury chloride up to a concentration of 0·0025 per cent. in the types of preparation used is almost completely ineffective as a protective spray against Potato Blight. In relation to the officially recommended 10 : 12·5 : 100 Bordeaux mixture this corresponds to a ratio of mercury to copper of about 1 : 159; in relation to the 8 : 10 : 100 Bordeaux used in 1942, of 1 : 127. Thus, unless a substantially higher concentration of mercury should become economically possible, there appears to be little prospect that this type of mercury compound will compete with copper preparations for the control of Potato Blight. In neither year was there any indication of

damage to the plants arising from the use of mercurial. The smallness of the difference in crop between the unsprayed and Bordeaux-sprayed plots is probably due to the lateness of the attack of Blight. By the time the foliage was seriously affected the variety used was nearing the end of its normal growth period.

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Summary.—Concentrations of phenyl mercury chloride up to 0·0025 per cent. failed to give appreciable control of Potato Blight on the variety British Queen grown at East Malling in the seasons 1941 and 1942. In each year the attack of Blight came late and Bordeaux spraying, though protecting the foliage against attack, did not result in a significant increase in yield over unsprayed plots.

Reference.

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HOPS

CULTURAL TRIALS WITH HOPS

III. THE EFFECT OF "STOPPING" AND NUMBER OF BINES PER STRING ON A VIGOROUS LATE VARIETY (OV7)

By F. H. BEARD

Introduction.—Hop-growers desire to get a heavy crop of well developed cones evenly distributed along the bine, together with a minimum of foliage. If the strings in late spring are furnished with the earliest bine produced, the resulting growth will in the majority of cases be far too vigorous. Rank bine tends to produce the bulk of the crop in the region of the top wire amongst a dense mass of foliage, thus making both picking and spraying difficult; the cones will tend to be poorly developed, a characteristic most marked in seasons of generally poor cone development. The presence of densely matted "heads" is particularly undesirable if picking is done by machine, though with hand-picking it will materially increase the cost of the operation. In order to encourage production of fruitful bine it is the custom to remove the earliest growths and train up the more backward shoots. The degree of severity of the "pulling" must largely be governed by the grower's experience of the variety on his soil. However, as the grower cannot tell what weather will follow later, he cannot always select the right bine for a particular season. If he pulls lightly and good growing weather prevails he will have too much bine growth; on the other hand if he pulls too severely and this is followed by unfavourable weather the resulting growth may be too weak to bear a full crop. Some of Professor Salmon's recent introductions, such as Brewer's Gold and Bullion Hop, are extremely vigorous, but in the spring they appear rather weak and only produce relatively few shoots, and are therefore likely to receive rather light pulling. Later in the season these varieties make very vigorous lateral growth, and when grown on the "Butcher system" the laterals cross over to the adjacent strings and become, in fact, miniature bines. As a result, these varieties tend to produce very tangled bine growth under ordinary methods of training.

It is obvious, therefore, that some method of controlling the growth at a later stage than that of the "pulling" would often be of considerable advantage. When the programme of hop research at East Malling was extended in 1926, it was decided to investigate the effect of the various cultural treatments that the hop crop receives, and to test modifications of these operations.

Trials. –In 1927 and 1928 small preliminary trials were made on a few hills of the variety Tutsham to test the effect of "stopping" the bine at various stages in its growth and training up the two top laterals in its place. The bines of some hills were stopped just above the lacing string and others between the lacing string and the breast wire. Both methods of stopping reduced the crop slightly, and stopping between lacing string and the breast wire forced into growth many barren laterals low down on the bine. In 1938 sufficient material was available to plant out a larger trial with one of Professor Salmon's new varieties, OV7. This is a late hop raised by crossing a Late Bavarian hop with an English male. At the time of planting it was considered to be one of the most promising new varieties, but it has since proved to be too late in season in an average year; however, its vigour made it a good variety for the purpose of the trial. A trial with an early hop of only moderate vigour had shown that the number of bines per string had a relatively slight influence on the cropping (Beard, 1937). It was thought desirable to see if the same held good with a vigorous variety, and a trial of 1, 2 and 3 bines per string was combined with the "stopping" trial. The trial contained eight randomized plots of fourteen hills for each number of bines; half the plots were "stopped" and half

allowed to grow unchecked after training. The " Butcher " system of wirework with 7 ft. alleys and 13 ft. 6 in. top wire was used. The hills were 7 ft. apart with three strings to a hill. The hills received normal pulling in the spring. From 1936 onwards the differential treatments were put in operation. In 1936 and 1937 the bines (on the " stopped " plots) were stopped at the top wire, but this was found to be insufficiently drastic as it did not greatly affect the formation of " heads ". From 1938 onwards the stopping was done at the lacing string, rather less than midway between the breast wire (4 ft. 6 in. from ground) and the top wire. This treatment was effective in preventing the formation of dense " heads ". The crop from each plot was picked and dried separately and from the weight of dried hops the yield per acre was estimated. The mean annual yields for the four plots in each treatment are shown in Table I. Yields for the variety as a whole were satisfactory in all seasons except in the years 1940 and 1941, both seasons of general low yields throughout the experimental hop garden.

TABLE I.

OV7 TRIAL YIELDS IN CWTS. PER ACRE 1936-42.

	Stopping at top wire.		Stopping at lacing string.					Mean.
	1936.	1937.	1938.	1939.	1940.	1941.	1942.	1938-42.
B1. 1 bine per string, not stopped ..	19·85	22·39	20·84	21·83	16·73	17·15	21·95	19·70
A1. ,, ,, stopped ..	19·42	19·70	15·31	17·43	15·59	15·87	20·27	16·89
Decrease in yield on " stopped " plots		*2·69*	*5·53*	*4·40*	*1·14*	*1·28*	*1·68*	*2·81*
B2. 2 bines per string, not stopped	18·86	22·23	21·52	22·26	17·29	19·99	22·54	20·72
A2. ,, ,, stopped ..	19·70	23·25	19·42	19·99	16·59	16·59	20·27	18·57
Decrease in yield on " stopped " plots			*2·10*	*2·27*	*0·70*	*3·40*	*2·27*	*2·15*
B3. 3 bines per string, not stopped	18·99	23·25	22·40	21·52	16·44	18·71	22·68	20·35
A3. ,, ,, stopped ..	18·57	22·82	19·42	21·12	16·59	17·01	20·70	18·97
Decrease in yield on " stopped " plots			*2·98*	*0·40*	—	*1·70*	*1·98*	*1·38*
Mean annual yield	19·23	22·27	19·82	20·69	16·54	17·55	21·40	

Effect of Stopping.—It will be seen from Table I that over the 5-year period 1938-42 " stopping " at the lacing string has reduced the crop on all numbers of bines though there have been variations in different seasons. Stopping significantly reduced the yield with all numbers of bines in 1938, 1941 and 1942, and with one and two bines per string in 1939, and with one bine per string in 1940. On the whole the reduction in crop has been greatest where only one bine was trained to each string and least with three bines to a string.

If the effect of stopping is considered for the three numbers of bines together the reduction in crop was significant in 1938, 1939, 1941 and 1942, and insignificant in 1940. The biggest reduction occurred in 1938, a season in which strong winds occurred at the time when the laterals were ready for training, causing the check to growth to be accentuated.

Stopping at the lacing string proved very effective in preventing the formation of heads and caused the crop to be borne well down the length of the bine. It is interesting to note that although stopping of the bines at the top wire in 1936 and 1937 did not appreciably effect the formation of heads it did cause a slight reduction in yield where each string was furnished with only one bine.

Effect of Number of Bines.—If the unstopped plots of series " B " are alone considered they provide four replicates in each number of bines and enable the effect of varying numbers of bines per string to be assessed. The yields from these plots are shown separately in Table II for easy reference. It will be seen that over the 7-year period 1936-42 the difference in yield has been so small as not to be significant. There are always a certain number of casualties amongst the bines after the

TABLE II.

OV7 TRIAL YIELDS IN CWTS. PER ACRE 1936-42. NUMBER OF BINES ONLY.

	1936.	1937.	1938.	1939.	1940.	1941.	1942.	Mean.
1 bine per string ..	19·85	22·39	20·84	21·83	16·73	17·15	21·95	19·70
2 ,, ,,	18·86	22·23	21·52	22·26	17·29	19·99	22·54	20·72
3 ,, ,,	18·99	23·25	22·40	21·52	16·59	18·71	22·68	20·35

strings have been furnished, due to accidents and to " growing off " (Fusarium Wilt). In order to assess this loss a survey was made just prior to picking each season from 1937 onwards, and the number of bines up each string recorded. For the 6-year period the average number of bines per string on

the " 1 bine " plots was 0·98, on the " 2 bine " plots 1·89, and on the " 3 bine " plots 2·75. The variation from plot to plot and season to season in the treatments was only slight. There was no correlation in any series between the mean number of bines per string and the cropping, not even in the case of the " 1 bine " plots which might be expected to show some such effect owing to the presence of blank strings when the mean number of bines per string is less than unity. When the hills were grubbed during the winter of 1942-43 it was noticed that the number of bines per string had materially affected the size of the rootstock. The hills which had 3 bines per string had a very large rootstock, and those with only 1 bine per string had a smaller than normal rootstock.

Discussion.—The trial has shown that whilst stopping of the bines at the lacing string with subsequent training up of laterals is effective in preventing the formation of heads, it does cause a reduction in yield. This reduction is to a certain extent offset by greater ease in spraying and picking. Where each string is furnished with one bine " stopping " is not required as the training of one bine is in itself a guarantee against excessive growth.

" Stopping " provides an alternative to severe pulling or the training of one bine per string, preventing excessive bine growth and has the advantage that it can be done later in the season than the other two methods.

It is not suggested that a grower should always practise stopping, but if he finds that owing to favourable weather conditions his bines are getting too forward he might well " stop " them with advantage.

Certain of Professor Salmon's introductions, notably Brewer's Gold and Bullion Hop, possess much greater vigour than the established commercial varieties and therefore need special care in cultivation if excessive bine growth with consequent difficult picking is to be avoided. The risk of " housy " bine may be reduced by (1) increasing the height of the wirework ; this is only practicable when planting a new garden, but is likely to be the most satisfactory method in the long run, leading to very heavy crops. Unfortunately it is not possible to test this experimentally on a small scale. (2) Furnishing each string with only one bine. (3) Stopping the bines. (4) By low nitrogenous manuring ; the preliminary results of a trial in progress indicate that this is not a satisfactory method as the cropping is reduced more than the bine growth.

It is intended to see which of methods 2 and 3 gives the best results with Brewer's Gold and Bullion Hop, and also to see if stopping the bines earlier (i.e. when they reach 4 ft. to 5 ft. from the ground) will check bine growth without reducing the yield.

Stopping at this level would also have the advantage that the subsequent training of the laterals could be done without the use of steps.

The negligible variations in cropping obtained by training up one, two and three bines per string are in line with those obtained in a trial with an early hop of moderate vigour (Beard, 1937), in which the number of bines per string had only a slight influence on the yield, though good cone development was favoured by fewer bines.

The results of the present trial show that in the case of a vigorous variety it is quite sufficient to furnish each string with one bine, and it is at present recommended that only one bine should be trained up in the case of Brewer's Gold and Bullion Hop. In gardens of the older varieties where bine growth is usually excessive, the cone development poor, and picking difficult, a great improvement would be made by training up only one bine per string, and there would be little, if any, reduction in yield.

In order to reduce the risk of blank strings occurring when only one bine is furnished to a string, it is suggested that two should be trained up in the first place and one of them cut through with a knife later in the season (June).

Acknowledgements.—The writer is indebted to Mr. T. N. Hoblyn for help in planning the trial, and to Mr. S. C. Pearce for the statistical examination of the data in each season.

Summary. –" Stopping " the bines at the lacing string (about 9 ft. from the ground) proved effective in preventing the formation of excessive " heads " over the top wire with a vigorous variety of hop when grown on the Butcher system of wirework. Over a five-year period " stopping " caused a reduction in yield which was greatest where one bine was trained up each string and least where each string was furnished with three bines. When grown without " stopping ", one bine per string gave yields not significantly lower than those of two and three bines per string. This is in line with the data obtained from an earlier trial with a variety of only moderate vigour.

The results are discussed with a view to commercial application.

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A COMPARISON OF THE PERFORMANCE OF SETS AND CUTS OF HOPS WHEN PLANTED IN THEIR PERMANENT POSITIONS

By F. H. BEARD

Introduction.—In this country hops are propagated almost entirely by means of the swollen bases of the past season's bine. These are known as " straps ", whilst still attached to the hill, and as " strap cuts " or " cuts " after removal. Well developed straps are obtained by earthing up the hills during the summer. As this also checks the formation of further shoots from the crown which are not needed once the strings are furnished, and also makes the " dressing " of the hills easier, it is the normal cultural practice. " Dressing " the hills consists of removing the surrounding soil and cutting the " straps " and any runners that may be present hard back to the crown of the rootstock. The operation is usually done in March but can be done at any time during the dormant period on the lighter soils where there is no danger of the hills lying wet if uncovered. Early dressing of the hills is of advantage if the " straps " are needed for propagation. When increase in stock is required the " strap cuts " are planted in a nursery to form sets (also known as " rooted sets "), which are lifted at the end of the season and planted out in the hop garden. Some growers, however, do plant the cuts direct into their permanent quarters, with, it is claimed, good results.

During the winters of 1940-41 and 1941-42 it was decided to grub and replant with better varieties a portion of the experimental hop garden at the Research Station. This provided an opportunity for comparing the performance of sets and cuts when planted direct into a hop garden.

Experiments. The hops used in both seasons were certain new varieties of merit raised by Professor E. S. Salmon at the S.-E. Agricultural College and tested at East Malling Research Station. In the 1941 trial the varieties Brewer's Gold (C9a), Bullion Hop (Q43) and R3/100 were used. These are sister varieties raised by crossing a wild hop from Manitoba (*Humulus americanus*) with an English male hop (*Humulus Lupulus*). All grow very vigorously and are remarkable for the large amount of lateral growth made late in the season. The trial contained four randomized plots of sixteen hills of both cuts and sets in each variety. In addition about $\frac{1}{2}$ acre was planted entirely with some exceptionally strong cuts of Brewer's Gold kindly given by a grower. Planting was done in March.

In 1942 the varieties used were Fillpocket (Z62) (second generation from the Oregon Cluster, the male parent in each case being an English hop), Brewer's Stand-by (HH44) (second generation from a Golding hop (B20) of unknown origin, the male parent in each generation being unknown), College Cluster (N15bis) (second generation from *Humulus americanus* var. *neo-mexicanus*, the male parents being unknown), OH44 (second generation from an ornamental variety " Golden Hop ", the male parent in each case being an English hop). These varieties are much less vigorous than those used in the previous season ; Fillpocket, Brewer's Stand-By, and OH44 are of normal vigour, whilst College Cluster, though a heavy cropper, is definitely a weak grower.

There were four randomized plots of fourteen hills each, of cuts and sets in the case of Fillpocket and Brewer's Stand-by, whilst with College Cluster and OH44 there were three randomized plots of sixteen hills each of cuts and sets. Planting was done in early January.

Each hill was planted with a single cut or set. In each season the plots were inspected prior to picking and each hill was graded by eye according to its vigour and cropping. The following table summarizes the results of this inspection. The grading for vigour was from 1 to 5 and for cropping from 0 to 5.

Comparison of Sets and Cuts 1941 and 1942.

	1941.						1942.							
	Brewer's Gold.		Bullion Hop.		R3/100.		Fillpocket.		Brewer's Stand-by.		College Cluster.		OH44.	
	cuts.	sets.	cuts.	sets.	cuts.	sets.	cuts.	sets.	cuts.	sets.	cuts.	sets.	cuts.	sets.
% Blanks ..	9	nil	14	nil	39	nil	44	nil	44	2	63	nil	52	nil
Average vigour	3·94	4·62	3·35	4·72	3·08	4·72	2·70	4·25	2·61	4·53	3·35	4·38	3·01	4·69
Average crop ..	2·46	4·02	1·35	3·67	0·76	4·02	0·18	1·27	0·24	1·92	0·86	2·52	0·39	2·09

Discussion of Results.—It will be seen that in both seasons there was a very heavy mortality amongst the cuts, with nearly every variety. The only exceptions being the home-saved cuts of Brewer's Gold and Bullion Hop with a mortality of 9 per cent. and 14 per cent. respectively. The half acre planted with the exceptionally strong cuts of Brewer's Gold supplied by a hop-grower had a mortality of 22 per cent. Having seen the two lots of cuts one would have expected the position to be reversed. Possibly the fact that the home-saved cuts were only exposed to the atmosphere for a short period may have compensated for their smaller size.

R3/100 had a higher mortality than the other two varieties in 1941 but the cuts were definitely of poorer quality.

The mortality in 1942 was higher than 1941 but whether this was due to the weaker varieties used, or to the season being more unfavourable, or a combination of both, it is not possible to say. The two seasons were both very unfavourable to growth of the young plants in the early part of the year. In 1941 it was not possible to do the planting until late, and rainfall was deficient from April to July. In 1942 planting was done earlier but the severe frosts which followed caused lifting of cuts and sets, the former being more affected owing to their poorer anchorage. Both cuts and sets were made firm by treading as soon as conditions allowed. June was abnormally dry and hot. The Research Station garden appears to have a relatively high wireworm population and at dressing time it is possible to find easily at least one wireworm at each hill. Whilst they do not seem to cause any appreciable damage to the mature hills nor to strong sets, it is likely that they may severely check or kill the weaker strap cuts. The experience of the writer over a long period of years is that under East Malling conditions a loss of 20 to 30 per cent. may be expected with cuts planted in the nursery, on fresh land apparently reasonably free from wireworms. Results from a trial in 1942 made to test the effect of treating cuts with a growth substance, gave mortalities of 24%, 32% and 17% for the untreated plots of Brewer's Gold, Bullion Hop, and Fuggle.

The planting of two or three cuts per hill would, of course, reduce the risk of failure, but it is doubtful if it would increase the vigour and cropping to any great extent. Unfortunately it was not possible to test this, as owing to the use of the area for future experiments it was desirable to have each hill composed of a single plant.

Though the seasons were not favourable, mortality amongst the sets was nil except in the case of HH44 and then it was only just over 2 per cent.

In 1941 both cuts and sets made vigorous growth though the sets were naturally rather more vigorous. There were slight differences in the average vigour between the cuts of the three varieties, Brewer's Gold being the most vigorous and R3/100 the least.

In 1942 the sets of all four varieties made good growth but the cuts made only moderate growth. The cuts of College Cluster (N15bis) and OH44 made less growth than Fillpocket and Brewer's Stand-by (HH44).

The crop from the sets in 1941 was good and that from the cuts was fair for Brewer's Gold, poor for Bullion Hop and almost negligible for R3/100. In 1942 the crop from the sets was on the whole poor, though College Cluster was definitely more croppy than the other varieties. The cuts of all four varieties had negligible crops, though here again College Cluster was better than the others.

There is some evidence that the plants from cuts are less croppy in relation to their vigour than the plants from sets. There are varietal differences in the relationship between vigour and cropping. Though the vigour of the R3/100 cuts was only slightly less than that of Brewer's Gold and Bullion Hop the crop was much poorer, and the crop of Bullion Hop was only about half that of Brewer's Gold. Bullion sets were less vigorous than those of Brewer's Gold but more croppy. Of the four varieties tested in 1942 College Cluster sets were the most croppy, though they did not differ appreciably in vigour from the other varieties.

The trials show that cuts of vigorous varieties such as Brewer's Gold and Bullion Hop, provided that a good " plant " is obtained, give a moderate crop in the first year. As a year is saved in establishing a garden there is a certain advantage in planting cuts of these varieties. Observations of the plants in their second season show there is no apparent difference between the plants derived from cuts and sets. It is, however, not possible to get reliable figures for the performance in the second season unless a 100 per cent. take of cuts can be obtained, as trials have shown that where gaps occur in the rows the yield per hill of the remaining hills is increased (Hoblyn and Amos, 1928).

With the weaker varieties where unfavourable conditions (wireworm, liability to dying out, late planting) are liable to exist the results of the above experiment clearly favour the planting of sets rather than cuts. On the other hand, there is the important question of the freedom of such sets from the soil-borne Verticillium Wilt disease, and experience has shown that cuts free from this disease may become readily infected in the nursery without developing any warning symptoms. If sets are used, therefore, the grower must satisfy himself that the nursery soil in which the disease-free cuts have been bedded has not previously carried wilt-susceptible crops (e.g. hop, potato, etc.), and that

it is adequately isolated from diseased plantations. As these conditions are not yet easily fulfilled, growers may prefer for the time being the safer course of planting direct with cuts from gardens known to be free from wilt, ensuring a good take by planting three to four cuts for every hill. Cuts should be planted as soon as possible after removal from the hill and if this is not feasible they should be bedded in soil or sand. If cuts have to be sent any distance, it will pay to pack them carefully in some damp material and not just loosely in sacks.

Summary.—An account is given comparing in two seasons the performance of sets and cuts when planted direct into their permanent positions. The trials were carried out on seven new varieties raised by Professor Salmon.

In both seasons and with all varieties there was a heavy mortality amongst the cuts. Sets gave a 100 per cent. take with all varieties except one in which there was a mortality of about 2 per cent. The plants from cuts were less croppy than those from sets. There were varietal differences in the cropping, which was not altogether correlated with vigour.

Suggestions are made as to when the planting of cuts or sets would be the more advantageous.

REFERENCE.

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COMMERCIAL VARIETIES OF HOPS: A PRELIMINARY COMPARISON OF THEIR CHIEF CHARACTERISTICS AT EAST MALLING

By F. H BEARD

Introduction.—During the nineteenth century a very large number of varieties were introduced and grown, but since then the number has gradually decreased and at the present time the hop acreage is almost entirely devoted to Fuggle, true Goldings, and " Golding Varieties ". During the past thirty-five years or so, Professor E. S. Salmon, of the S.-E. Agricultural College, has bred a large number of new varieties, several of which are now being grown commercially on a limited scale. However, it is not intended to include these varieties in the scope of the present paper, and the term " Commercial Variety " is used to designate those varieties in general cultivation. Professor Salmon's introductions are usually referred to as " New " or " Wye " varieties.

All English (other than those raised by Professor Salmon) and Continental varieties belong to the botanical species, *Humulus Lupulus* L. Salmon and Wormald (1915) have shown that the American wild hop is a distinct species, *Humulus americanus* Nutt. American cultivated varieties either belong to this species or are, like many of Professor Salmon's varieties, hybrids between the two species.

The hop plant is dioecious* and all cultivated varieties are females. There are no recognized varieties of male hop ; the grower is interested only that it should flower at the correct time to pollinate his female variety. Male hops are therefore classified according to season. Wormald (1915), however, found that great differences in botanical character exist between individual plants.

Commercial varieties have arisen either as chance seedlings (e.g. Fuggle, Colgate) or more commonly as selections from existing varieties (e.g. Early Bird, Rodmersham Golding). In the case of the selections it is likely that these have been " bud sports " or mutations and this is dealt with in greater detail later.

Since the hop is dioecious it does not breed true, for the female plants are pollinated from males of unknown potentialities. Also about half the seedlings will be male hops. Therefore unless it is desired to raise new varieties, hops are always propagated vegetatively either by means of cuttings from the below ground portion of the past season's bine or by underground runners. The former method is the usual one in this country, whilst runners are used in America. As propagation is always vegetative each variety should in theory be a " clone ".

Origin of Collections at East Malling.—In order to make a true comparison between different varieties it is essential to have them growing under similar conditions. Professor Salmon therefore obtained sets of the principal commercial varieties, from what were considered to be the best and most reliable sources of supply, to grow alongside his new varieties for comparison. In the case of Fuggle many growers claimed that they had " strains " of particular merit, so that Fuggles from a large number of sources were planted for comparison.

* In the case of *H. americanus* and its hybrids, female plants sometimes bear branches of male inflorescences in variable amount.

Varieties received under the following names have been grown in the experimental gardens at one time or another : Prolifics, Bates' Brewer, Tolhurst, Meopham, Fuggle (from many sources), Guilton Golding, Tutsham, Cobbs, Farnham Whitebine, Cooper's White, Canterbury, Eastwell, Rodmersham and Petham Goldings, Bramling, Early Bird, Mathon and Colgate.

Prolifics and Bates' Brewer, though considered to be distinct varieties, were discarded from the collection at an early date, the former on account of its poor quality and the latter for its poor cropping. Prolifics did not show symptoms of Mosaic disease but Bates' Brewer proved susceptible. The stock of Farnham Whitebine, Cooper's White and Cobbs were lost through the ravages of Mosaic.

The crop from the rows of the various varieties was picked separately, the yield per acre estimated, and analyses for P.V. made. From 1921 to 1926 samples of many of the commercial varieties together with certain of the new varieties were sent under cypher numbers to factors, merchants and brewers for physical examination for evaluation (Salmon, 1922-28). The reports received were very varied and sometimes contradictory. For example the reports on the sample of Petham Golding in 1922 were as follows : Good Golding flavour (Factor 1) ; thin hop rather dry, distinct but weak flavour (Factor 2) ; fair rub and flavour (Merchant) ; quite a nice flavour but somewhat of the Fuggle type (Brewer 1) ; bright, ripe hops, buttony but rather small, flavour good but not much of it (Brewer 2) ; small, good side, closely resembling No. 20* (Brewer 3) ; stout copper hop, slight Colgate aroma (Brewer 4).

The opinions of the factors were fairly uniform, whilst those of the brewers were more variable. The factors often identified a sample as a " Golding " though the actual variety was not named ; the Fuggle was often identified by name. Though there was a great variation in the opinions expressed there was considerable uniformity as to the best and worst samples.

Preliminary trial indicated that most of the lesser grown varieties were not worthy of further testing and they were discarded.

Whilst varieties such as Fuggle, Tolhurst and Colgate and the majority of the new varieties flourished in the experimental hop garden, others such as the several Goldings, the " Golding Varieties " and certain of the new varieties, rapidly succumbed to the Mosaic disease, in many cases to such an extent that the variety could only be kept in being by the frequent introduction of fresh stock from outside. It became quite impossible to assess the yields of the affected varieties. It was then found that " Mosaic " was a virus disease and that the apparently healthy new varieties were acting as carriers of the disease and causing the infection of the susceptible varieties growing in their vicinity. At a later date it was shown that the Fuggle is also a potential carrier and it is now considered that all varieties which do not show symptoms of the disease are actual or potential carriers.

In order, therefore, to maintain disease-free stock of the susceptible varieties, it was necessary to grow them in isolation from the main garden of New Varieties and Fuggles.

Raising of Clonal Races. —Work on the classification and identification of soft fruits at East Malling had shown that many commercial stocks were mixed and that a single variety might have more than one name. Therefore, when the programme of hop research was extended in 1926 it was thought desirable to undertake similar work on the classification and identification of hop varieties, and finally to test them for cropping and brewing value. In order to have uniform material, clones were raised from single selected hills of certain of the varieties collected by Professor Salmon. The work has been greatly hampered by the disease factor mentioned earlier but some progress has been made. As the stage has now been reached when it is possible to plant a cropping trial with seven clonal named varieties of Goldings, and as several seasons' data are available from a trial of three Fuggle strains, it seems an appropriate time to summarize the information to date.

Preliminary Classification. —Varieties can first be divided into three rough groups according to bine colour and then sub-divided on colour of petiole (leaf-stalk). Season and cone characteristics may also be helpful. It should be mentioned that the best time for identifying hops is from the end of June onwards. Young plants and those suffering from any of the virus diseases cannot be readily identified.

I. Green Bine Varieties.

(*a*) *Petiole Green. Colgate.*—Bine and petiole are rather rough, cones are small, tight and bright green, and it is very late in season. It has not shown symptoms of Mosaic disease. The original plant is said to have been found growing wild near Chevening, Kent, in the early nineteenth century by a Mr. Colgate. It was grown on the heavier lands of Sussex and Kent, but owing to its poor quality, rank aroma and lateness has passed out of general cultivation. For these reasons it has not been retained in the East Malling collection.

(*b*) *Petiole coloured purplish-red on upper surface. Fuggle.*—The coloration is quite distinct from the brighter red found on the petiole of Goldings, and is the easiest way of identifying the variety.

* = M45, one of Professor Salmon's seedling varieties.

Cones are medium-large or very large (the size depending largely on cultural and soil conditions) somewhat coarse, loose, and squarish in cross section, and borne on relatively short laterals. It does not usually make much growth after about mid-summer. On the lighter soils it is only moderate in vigour, but on the heavier soils, where it is most grown, growth can be vigorous.

The original Fuggle arose as a chance seedling found growing at Horsmonden, Kent, in 1861, and was introduced into cultivation by Mr. R. Fuggle of Brenchley, Kent, about 1875. It is the most grown of any variety at the present time and is practically the only variety grown on the heavier lands of Kent and Sussex. It is a symptomless carrier of the Mosaic disease but is susceptible to the virus disease known as " Nettlehead ".

Strains of Fuggle.—Short rows of from 15 to 30 hills of commercial samples of Fuggle from some thirteen sources in Kent, Sussex, West Midlands and Canada have been grown in the experimental hop garden. These have shown no botanical differences.

Figures for a number of the rows of commercial samples of Fuggle from various sources show differences in P.V. which are probably not significant (Salmon, 1927-39). For instance in 1929 samples from eight rows of different " strains " all gave a P.V. (10α) between 59 and 63.

The variety received as Guilton Golding proved to be indistinguishable from the Fuggle. Three selections of Fuggle from two Kent and one Sussex source were raised from single plants and planted out in 1931 as a statistically planned cropping trial. In Table I the mean crop is based on eight plots

TABLE I.

COMPARISON OF FUGGLE CLONES.

Crops 1935-1942. *Cwt. per acre.*

	1935.	1936.	1937.	1938.	1939.	1940.	1941.	1942.	Mean.
Fuggle Strain A ..	17·25)	20·92)	17·75)	15·97)	20·46)	16·95)	11·65)	15·71)	17·08
Fuggle Strain L ..	18·18)	21·75)	17·12)	16·12)	21·35)	17·03)	10·91*)	16·04)	17·31
Fuggle Strain N ..	20·01	24·22	19·43	18·03	22·74	18·60	14·14	19·26	19·55
Mean	18·48	22·30	18·10	16·71	21·52	17·53	12·23	17·00	17·98

* Yield reduced by severe " Split-leaf Blotch ".

Figures in brackets do not differ significantly.

of each strain ; strain " N " in each season from 1935, when the crop was measured for the first time, has given consistently heavier crops. The differences between the other two strains have in no season been significant, and their means for the eight season period are practically identical. There are, however, some grounds for believing that strain " L " is a slightly heavier cropper than strain " A ". In every season except two it has had the slightly heavier crop. In 1937 the two strains were almost identical in yield, whilst in 1941 the yield of strain " L " was reduced by a severe outbreak of " Split-leaf Blotch ".

There has been no difference between the strains in the number of bushels of green hops needed to give a cwt. of dried hops.

The heaviest cropping strain " N " was the most resistant to injury in the severe May frost of 1935.

Analyses* of three strains in two seasons 1941, 1942, show only small differences which are probably not significant. The actual P.V. (10α) for the two seasons was Fuggle " A " 55, 56, Fuggle " L " 59, 56, Fuggle " N " 55, 53.

II. Red Bine Varieties.

Tolhurst.—This variety is early midseason, bears very large, coarse, loose cones, somewhat similar in shape to the Fuggle but much coarser. It is of very poor quality with hardly any of the valuable α resins (see Table V) and has a very rank aroma. For these reasons it has largely passed out of cultivation and is no longer grown at the Research Station.

III. Mottled Bine Varieties.

A very large number of varieties fall into this class. They can, however, be divided into two groups according to the type of cone.

(*a*) *True Goldings.*—These have medium-small, round compact, cylindrical cones, pale in colour, and with a relatively high number (for their size) of petals. Preliminary observations on the seven clones of named varieties of true Goldings —Bramling, Canterbury Golding, Early Bird, Eastwell Golding, Mathon, Petham and Rodmersham —showed that there was no clear botanical differences by

* Analyses made by Mr. J. S. Ford at Messrs. Wm. Younger & Co.'s Brewery, Edinburgh.

which these varieties could be readily identified. Very detailed observations and records were made on these varieties and the data collected is summarized below.

Bine.—The mature bine of all true Goldings is green with more or less mottling of red. There is great variation in the amount of red mottling both from bine to bine in the same plant and from season to season. Bramling, Early Bird and Canterbury Golding have on the whole redder bine, whilst that of Petham Golding is definitely more green. The bines of Rodmersham Golding, Eastwell Golding and Mathon are intermediate.

The small collection of Goldings has been grown in isolation on ground different from that of the main hop garden and it has favoured strong bine growth. All varieties have made good growth, but Bramling, Early Bird and Canterbury Golding have been the weakest whilst Petham Golding has been the most vigorous. The vigour of Canterbury Golding cannot, however, be considered typical of the variety as it has suffered severely from attacks of Downy Mildew* (*Pseudoperonospora Humuli*) and hills have been killed (and replanted) and weakened by the disease.

Petioles and Leaves.—In 1938 and 1939 leaves were taken at random at about 5 ft. to 6 ft. from ground level (between breast wire and lacing string) from the seven Goldings and also for comparison from the three clonal Fuggle. Two leaves were taken from each hill to a total of twenty leaves for each variety. The colour of the upper surface of the petioles in the Goldings was, like that of the bine, very variable both from leaf to leaf and from season to season. When red coloration was present it was brighter and quite distinct from the always present dull purplish-red which is characteristic of the Fuggle. There was more coloration of the petioles in 1938 than in 1939, both in intensity and the number of petioles showing red. In 1938 Bramling, Early Bird and Canterbury Golding had more coloured petioles, and the colour was more intense than that of the other Goldings. In 1939 all varieties had more leaves with green petioles, and red coloration, when present, was not great, whilst all the sample leaves of Petham Golding had green petioles.

Measurements were made of the length of petiole, length of leaf, greatest breadth of leaf, and length of the terminal lobe. The leaves were very uniform in size and there were no significant differences between the varieties. The average length of petiole was around 8-10 cm., the average length of leaf about 19 cm., and the greatest breadth of the leaves was usually about 1 cm. greater than the length. The length of the terminal lobe was proportionate to the length of the leaf, being around 8-9 cm. In addition to the above measurements notes were made on the basal sinus. Leaves with wide and narrow sinuses occurred in all the Goldings.

Glands on Leaves.—On the under surface of the leaves are glandular hairs, easily seen with a pocket lens, which closely resemble the lupulin glands of the female inflorescence (hop cone). Wormald (1915) and Salmon and Wormald (1921) found in the case of male hops and seedlings of wild hops from abroad, that, though there was great variation between individual counts on leaves of the same plant, there were also differences in the average number per plant. It was therefore thought possible that there might be variations in number of glands between the several Goldings. Counts were therefore made on sample leaves in 1938 and 1939. The method used was that adopted by Salmon and Wormald, in which a count was made of the number of glands visible in a $\frac{1}{4}$ in. circle midway between the base of the lamina and one of the two sinuses at the base of the terminal lobe. Two readings were thus obtained from each leaf. In 1938 ten leaves, and in 1939 twenty leaves of each variety were examined.

There were very great differences in the counts for different leaves of the same variety, readings being in some cases as high as 78 and as low as 5, though such extremes were not common. The variation between the two readings for the same leaf was much less. A statistical examination of the figures shows that the variety Bramling had significantly fewer glands and that Canterbury Golding had rather more glands than the other varieties, though the difference in the latter case is only suggestive and not truly significant.

Cones.—Owing to the need for growing the Goldings in isolation away from the main hop garden and the difficulty of establishing suitable " non-carrier " males, pollination has not been completely satisfactory, and the degree of seediness has varied from season to season between the varieties. All seven Goldings have had cones of similar type. They have been of the recognized " Golding " type, being medium-small, firm, and round in cross section. In 1938 samples were saved of the dried cones of the seven Goldings and also of Tutsham and Fuggle for comparison. From these samples fifty cones were taken at random, and the length of cone and strig measured, and the number of " petals " counted. The " petals " of a hop cone consist of bracts which are sterile, and bracteoles which bear seed when pollination has been effective. For each bract present there are two bracteoles. Salmon and Amos (1908) have shown that the length of cone in a particular variety is dependent on two factors, (i) the number of petals and (ii) the proportion of bracteoles bearing seeds. In Table II is

* This susceptibility has also been reported on another strain grown under this name at Wye (Burgess, A. H., 1932-39).

given the average length of cone and strig, number of petals per cone, the number of petals per unit length of strig and a note as to the seediness of the sample.

TABLE II.

COMPARISON OF CONES FROM CLONAL SELECTIONS OF NINE NAMED VARIETIES (1938).
Mean of 50 Cones.

Variety.	Av. length of cones cm.	Av. length of strig cm.	Av. No. of petals.	No. of petals per cm. of strig.	Remarks.
Fuggle	3·48	2·32	50	21·2	Well seeded.
Petham Golding ..	3·08	2·09	54	25·3	Poorly seeded.
Tutsham	3·04	2·06	50	24·3	Moderately seeded.
Early Bird	2·98	1·99	52	26·1	,, ,,
Mathon	2·80	1·76	46	26·1	,, ,,
Eastwell Golding ..	2·74	1·80	48	26·7	Poorly seeded.
Rodmersham	2·72	1·65	50	30·3	,, ,,
Bramling	2·66	1·78	50	28·1	Moderately seeded.
Canterbury Golding ..	2·51	1·59	49	30·8	,, ,,

Though there is not a great variation in the number of petals per cone, statistical examination of the data shows that Mathon had significantly fewer petals than Bramling, Early Bird, Rodmersham Golding, and incidentally Tutsham, but does not differ significantly from Eastwell and Canterbury Goldings ; Petham Golding has significantly more petals than all varieties except Early Bird.

Though the number of petals is not altered by the degree of pollination it is possible that it may be influenced by environmental conditions. For this reason the figure for the Fuggle is not strictly comparable with the others as the variety was grown in a separate garden.

The number of petals per unit length of the strig, is of course, greatly influenced by the amount of seed present. Many seeded bracteoles will depress the number and few seeded bracteoles will have the opposite effect. The figures for the Goldings and Tutsham are therefore higher than they would be if the cones had been well pollinated. The highest numbers were for Petham, Eastwell and Rodmersham Goldings, as these were the least well seeded. However, these do not all have equally high numbers, the first two varieties having a lower number than Rodmersham Golding. It is therefore likely that there are differences in the number of petals per unit length of strig between the several Goldings.

There is evidence that Petham Golding has larger cones than the other six Goldings, for in spite of being poorly seeded it had the largest cones.

The figure of 3·48 cm. as the average length of Fuggle cones should not be taken as typical of this variety, as under East Malling conditions the variety does not develop the large cones which are found in many gardens on the heavier lands. These larger cones possibly have more petals also.

Season.—Table III shows the order in which the seven Goldings have come into burr and hop for the years 1937-42. It will be seen that in most seasons the order of flowering (burr) is not identical with that of cone formation. It is possible that the order of ripening might be different from both.

TABLE III.

ORDER OF FLOWERING AND COMING INTO HOP OF SEVEN CLONAL SELECTIONS OF NAMED GOLDINGS.

	1937.		1938.		1939.		1940.		1941.		1942.	
	Burr.	Hop.	Burr.	Hop.	Burr.	Hop.	Burr.	Hop.	Burr.	Hop.	Burr.	Hop.
Early Bird	1	1	1	1	1	1	1	1	1	1	1	2
Bramling	1	2	2	1	1	1	2	1	1	2	1	1
Rodmersham Golding ..	2	4	4	3	2	2	3	3	2	4	3	4
Eastwell Golding	3	4	3	2	2	2	4	2	2	3	3	4
Petham Golding	2	3	5	3	2	2	4	2	2	4	2	3
Mathon	3	4	4	3	3	3	5	3	2	4	3	5
Canterbury Golding ..	3	4	5	4	3	3	5	4	3	4	3	5

Unfortunately complete data on this are not at present available, as owing to the isolated position of the garden and the small area involved it has been necessary to harvest the varieties in two pickings —the first consisting of Bramling and Early Bird and the second of the remaining five varieties.

Bramling and Early Bird have always been the first to come into burr and hop. Early Bird is inclined to be a few days earlier than Bramling, though sometimes there has been no difference, and once (1942) Early Bird was later in coming into hop. Canterbury Golding and Mathon have been definitely late in season, the former being the later of the two. Rodmersham, Eastwell and Petham Goldings, though their relative order varied from year to year, have occupied an intermediate position. If the order is based only on the time of coming into hop, Rodmersham Golding has been later than the other two. The variation in season between the varieties from year to year is not exceptional. Observations on the large number of New Varieties growing in the main hop garden show that there is variation in the order in which they come into burr and into hop from season to season, and that only after several seasons' records is it possible, except with extreme cases, to group them roughly according to season.

P.V.—Figures for the P.V. of the seven clonal Goldings are only available for 1938, as owing to war conditions the analytical work has been greatly restricted. The figures for 1938 are given in Table IV, estimations both by the new (10α) and older ($(\alpha + \beta/3)10$) are given. Tutsham and a commercial strain of Fuggle are included for comparison. There are no great differences in P.V.

TABLE IV.

P.V. OF NINE CLONAL SELECTIONS OF NAMED VARIETIES OF HOPS.

	1938.	
	10α	$(\alpha + \beta/3)10$.
Early Bird	68	94
Bramling	39	64
Rodmersham Golding	49	73
Eastwell Golding	55	86
Petham Golding	54	77
Mathon	55	86
Canterbury Golding	58	84
Tutsham	53	82
Fuggle (commercial selection) ..	52	80

except in the case of Bramling and Early Bird. The former has a rather low, and the latter a somewhat high P.V. These two varieties were also analysed in 1937 when Early Bird was again richer than the Bramling (10α 81 compared with 58).

Although the analysis of the seven clonal Goldings was only made in one season, figures are available for commercial strains of many varieties grown at East Malling, and these are given in Table V. It will be noticed that on the whole there is no very great difference in P.V. between the Goldings, "Golding Varieties", and Fuggle, though on the average Canterbury Golding has had the highest P.V. The Bramling in this table is not from the same source as that in the clonal selection. The varieties, Colgate, Meopham, Prolifics and Tolhurst which are little grown to-day, have much lower P.V. than the Goldings, "Golding Varieties", and Fuggle, and in the case of Tolhurst the valuable α resins are almost entirely absent.

(*b*) "*Golding Varieties.*"—This name is not a satisfactory one as it leads to confusion with "varieties of Goldings". However, it is used to describe the varieties Cobbs and Tutsham, which differ from the true Goldings in having larger, looser and rather coarser cones. So far it has not been possible to compare these two varieties owing to the incidence of disease. The original clonal stock of Cobbs was destroyed by Mosaic disease, and when a new stock had been established, the clone of Tutsham had to be eliminated owing to all hills showing severe "Split-leaf Blotch" in two seasons.

Conclusions.—Whilst Tolhurst, Colgate and Fuggle appear to be distinct varieties which can readily be identified, the true Goldings, though readily distinguishable from non-Goldings and from "Golding Varieties" are not readily distinguishable amongst themselves. However, there are small differences between the seven clonal Goldings that have been grown at the Research Station, of which perhaps season serves as the best initial guide.

EARLY. *Bramling.* Early in season, relatively few glands on lower surface of leaves, rather lower P.V. than other six Goldings, bine redder than all varieties except Canterbury Golding.

Early Bird. Usually a few days earlier than Bramling, rather higher P.V.

Table V.

P.V. of Commercial Varieties Grown at East Malling 1927-1934.

	1927.		1928.		1929.		1930.		1931.		1932.		1933.		1934.	
	1. 10α	2. $(\alpha+\beta/3)10$	1. 10α	2. $(\alpha+\beta/3)10$	1. 10α	2. $(\alpha+\beta/3)10$	1 10α	2. $(\alpha+\beta/3)10$	1 10α	2. $(\alpha+\beta/3)10$	1. 10α	2. $(\alpha+\beta/3)10$	1. 10α	2. $(\alpha+\beta/3)10$	1. 10α	2. $(\alpha+\beta/3)10$
Goldings.																
Bramling ..	43	68	47	73	54	71	61	82	34	64	62	89				
Rodmersham Golding ..	34	59	50	73	55	72	63	86	40	61	56	86	47	75	51	80
Eastwell Golding ..	52	76	45	72												
Petham Golding ..	52	78	58	97	57	79	75	97	42	67	64	97	46	74	50	81
Mathon ..			48	78					44	67						
Canterbury Golding ..	**54**	**81**	53	83	**66**	85	**78**	**102**	**51**	**77**	60	95	51	81	**64**	**95**
Golding Varieties.																
Cobbs ..													55	84		
Tutsham ..	42	67	47	71	53	70	57	75	35	73						
Other Varieties.																
Fuggle L. ..					61	**86**	55	73			55	87	**59**	**90**	53	83
Fuggle W. ..	41	70	55	84	59	79	48	65	43	67	59	90	**59**	**90**	52	91
Colgate ..	32	58	43	68	50	69										
Tolhurst ..	7	37	4	36												
Meopham ..									23	45						
Prolific ..	34	58														

Numbers in heavy type show the highest P.V. values for each year.

MIDSEASON. *Eastwell Goldings.* Midseason, rather fewer petals per cone than the other six varieties.

Petham Golding. Midseason, greener bine, larger cones, with more petals than other varieties.

Rodmersham Golding. Midseason, but later than above two in coming into burr.

LATE. *Mathon.* Late in season, fewest petals per cone.

Canterbury Golding. Later in season than Mathon, very susceptible to Downy Mildew. The analyses of the hops from rows of commercial strains show that on an average this is the richest in resins of all the commercial varieties.

Discussion.—The varieties Tolhurst, Colgate and Fuggle may be considered as being distinct varieties which have arisen as seedlings. The latter two varieties are known to have arisen as chance seedlings. The small variation exhibited by the Goldings may be explained on the assumption that they have all arisen as selections ("bud-sports") from an original parent type. The original "Golding" is said to have been raised by selection from the "Canterbury Hop" by a Mr. Golding of the Malling district of Kent at the end of the eighteenth century. Rodmersham Golding is known to be a selection from the original Golding, and Early Bird was selected from the Bramling by Mr. Alfred Amos of Wye at the end of the nineteenth century. New varieties arising as "bud-sports" are known to occur in the case of a large number of vegetatively propagated crops, such as potato, apple, plum, peach, pineapple. sugar cane, etc.

There is evidence that the formation of adventitious buds by means of injury, such as severe cutting back encourages the formation of "bud-sports". If the eyes of certain potato varieties are removed, thereby causing the formation of adventitious buds from deeper tissue, "bud-sports" are formed (Crane, 1936). The severe dressing that the hop hills receive annually may therefore favour the production of bud-sports. It is known that in an occasional Fuggle garden a plant is often found earlier in season than normal, yet definitely identifiable as Fuggle. The writer has also noticed a single variegated hill of "Brewer's Favourite" growing in the half-acre of that variety at East Malling.

More recently Salmon (1940) has found "bud-sports", richer in resins than the original variety, occurring in one of his new varieties, "Nonsuch Hop" (OB53).

It is obvious that if "bud-sports" occur not uncommonly among the Goldings, and that certain variations of promise have been selected by growers as a nucleus of a new variety, it is likely that many minor variations also occur and pass unnoticed. There is, too, the possibility that after the selection of a particular plant as a "New Variety" further variations may occur during a long period of vegetative reproduction. Though the careful and observant grower will tend either to rogue out or to select obvious variants, the less observant ones will not, so that in course of time some "strains" of a variety may become less uniform than others. It is a common practice to grub and replant hop gardens and in these circumstances some pieces of the original variety are sure to survive the grubbing, and if the newly planted variety is very similar to that grubbed as in the case of the Goldings it is impossible to "rogue" the garden effectively.

For the above reasons it is likely that considerable variation may occur between individual hills in a Golding garden, and varieties of the same name in different gardens may not be identical. The seven clonal Goldings grown at East Malling may not necessarily be typical of others grown elsewhere under similar names.

During the relatively short period that the clones have been under observation there have been no variant plants observed within a clone. It must, however, be remembered that so far only from 15 to 30 plants of each clone have been under observation and that it is not likely that "bud-sports" occur with great frequency.

In Kent stocks of Goldings are comparatively free from disease but in the West Midland area where they are grown in proximity to the Fuggle there is a large amount of Mosaic present. In Kent the Goldings are mainly found in East Kent, and the Fuggle in the Weald.

The Fuggle is such a distinct variety that on the whole the stocks are fairly free from rogues though an occasional "wild" hill (probably a seedling) is found, and the Tolhurst occurs as a rogue where gardens of this now discarded variety have been replanted with Fuggle. The results of the cropping trial at East Malling have shown that substantial and consistent differences in cropping between clonal races do exist. Commercial gardens may quite possibly consist of a mixture of hills of varying cropping capacity. Though gardens of Fuggle can be found showing a wide range of vigour and cone development, it seems that this is mostly due to environmental factors, such as soil and degree of pollination, since when strains from many sources are grown under similar conditions in the East Malling gardens no difference is apparent.

Though stocks of Fuggle may be considered reasonably free from rogues, the disease factor is a serious problem at the present time. Many stocks are seriously affected with Nettlehead, and Verticillium Wilt.

The results of the work to date suggest that apart from the disease factor, it is desirable from time to time to re-select strains of varieties which have been cultivated for a long time if they are to be kept true to type and free from rogues. The ideal thing would be to propagate from special nursery gardens on the lines of the East Malling daughter nurseries for strawberries and raspberries. These small intensive areas could be inspected much more thoroughly than would be possible with large scale gardens. It would appear desirable to investigate the hill to hill variation in P.V. in both clonal and non-clonal stock at a future date when facilities are again available for this work.

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Summary.—An account is given of the investigations so far made on the Commercial Varieties of Hops. Whilst Fuggle, Colgate and Tolhurst are distinct varieties easily identified, the true Goldings though clearly distinguishable from non-Goldings show only minor differences between themselves.

Seven clones raised from Goldings received under different names have shown differences in season, size of cones, number of petals, number of glands on the leaves, resin content of cones, slight variation in bine colour, and susceptibility to disease. The similarity between the Goldings is explained on the assumption that all are derived as " bud-sports " from a common parent type.

A cropping trial with three clonal strains of Fuggle has shown differences in yield and resistance to frost injury.

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Section IV

BULLETINS FOR FRUITGROWERS

RAISING ROOTSTOCKS

By R. J. GARNER

Introduction.—Tree raising is a specialist's job. The nursery, as its name implies, is a place in which trees are born and nursed until they are fit to hold their own in the plantation. This nursing demands constant skilled attention which can only be given when the subject is a main line as opposed to a side line. Almost invariably the fruit-grower's nursery, as distinct from the tree raiser's nursery, is uneconomical, yielding poorly because of the lack of proper attention at the proper time. Trees must remain in the nursery at least two years, not counting the time needed to raise the rootstock, and for trees to be available in a particular year the project must be initiated three or four years ahead. Moreover, to ensure a sufficiency, far more trees must be handled than are finally required. The regular output of a tree raiser's nursery overcomes these stringencies of supply and demand.

When the war began the planting of fruit-trees was restricted by cropping orders, and rootstock raisers were encouraged to grub a proportion of their stoolbeds, and other nursery areas, and to grow staple food crops. At this time the East Malling Research Station was cultivating about 10 acres of stoolbeds of rootstocks in general use. These 10 acres had come into existence in the following way. Prior to 1927 the Research Station had identified and classified rootstocks for all the common fruits, had established nuclear stocks of these at East Malling, and was making a small annual distribution to the trade and to educational institutes. With the increased demand for their clonal material came the request for an expansion of output. The suggestion that a co-operative rootstock nursery should be established and maintained by the trade did not materialize, and in its stead the trade asked East Malling to lay down larger stoolbeds for the annual production of three to five hundred thousand rootstocks of various kinds. By plantings in 1927 and following years 10 acres of stoolbeds were established which were soon producing annually up to half a million rootstocks. In 1939 the demand for rootstocks was greatly reduced following upon the uncertainties of the time and the restrictions previously mentioned. At the end of that season large quantities remained unsold and had to be burnt. An effort was made to reduce the stoolbed area but, perhaps fortunately, labour was scarce and only some three acres were cleared.

With the progress of the war the amateur's interest in planting fruit increased and this, combined with the grubbing and replacement of derelict orchards and the improvement of others, brought about a marked increase in the demand for trees. This demand was reflected in a phenomenal rise in the applications received at East Malling for the supply of rootstocks. The output in no way satisfied the demand and instead of requests to reduce output the Research Station was asked to lay down additional stoolbeds as early as possible.

A new 10 acres is now planted but it will be some few years before this new area reaches full production, by which time what remains of the original area will be uneconomic. When this happens these rootstock stoolbeds will only partly satisfy tree raisers' needs. There is evidence that home supplies of rootstocks are insufficient for immediate use as frequent applications are received for the identification of rootstocks procured from tree suckers. In peacetime large importations were usual, the annual total running into millions.

Because of immediate needs and likely severe shortages in the future, tree raisers have shown a greatly increased interest in rootstock propagation and we have already received many applications for details of the methods which have proved successful at East Malling and now to be briefly described.

A Comparison of the Methods.—It is convenient to consider methods under two heads. First, stooling and layering; under this head may be included all processes in which the progeny remain attached to the parent until they possess both roots and shoots. Second, cuttings which involve removal of portions of the parent plant and the subsequent production of roots and shoots. Stooling and layering are by far the most widely used at East Malling. Cuttings are only used at present for two plum rootstocks and, on a small scale, for quinces. Root-cuttings are not employed on any large scale at East Malling, but the few thousands rooted in past years have shown that the method is successful, provided suitable material is available in sufficient quantity. The procedure outlined is the normal one long in use by tree raisers for the propagation of certain plum rootstocks.

With the exception of M. XII, which roots poorly until the stool has been in position for some years, all the Malling series of apple rootstocks M. I to XVI and the quinces, Malling A, B and C, are readily propagated by the stool method.

All the plum rootstocks in general use, except Marianna, are propagated by layering, involving etiolation. Selected Mazzard cherries (*Prunus avium*) root readily when similarly layered.

Selected "free" pear rootstocks have proved shy rooters and vegetative propagation of these has not so far proved a commercial proposition in any form. Layering of pears with etiolation has so far given only fair results in some few seasons. The plum rootstocks Marianna and Myrobolan B are fairly readily propagated by hardwood cuttings as are also the quinces, provided suitable material is used and set in a favourable situation. However, the quince rootstocks are so prolific on stools that it is doubtful if cuttings could compete with them as a main source of rootstocks.

In judging the merits of any particular method the area of ground occupied by the parent, the amount of work entailed in its care, and the time taken to reach the "lining out for budding" stage should be taken into account together with rooting capacity. Another important factor, often ignored, is the age and shape of the rootstock when ready for working. Rooted shoots direct from layers, usually known as "one-year layers", have thin bark, are straight and therefore convenient to bundle and to cultivate in the nursery row. Whereas rooted hardwood cuttings are at least a year older in the stem and therefore have thicker bark and are more difficult to bundle and to cultivate.

The time of year when labour is required may help to decide the methods to be adopted. Stools and layers require much labour in the early summer whereas, except for hoeing, hardwood and root cuttings require little labour at this time but are largely handled in the autumn and winter. It may be that stools and layers may be run in conjunction with cuttings in such proportion that the heavy demand on labour in the summer does not absorb the whole staff for a period in which other activities are neglected. However, all these considerations are often outweighed by the fact that any one particular kind of rootstock is best propagated in one particular way. An outstanding example is the Marianna plum which roots readily as a hardwood cutting, but only poorly when layered.

The successful technique employed for rootstocks in common use is set out in Table I. The exclusion of a variety from the column marked layering, and its inclusion under stooling, means that it is propagated readily on stools and that layering with its extra cost is not called for, though layering has proved efficacious with almost all plants subjected to it.

TABLE I.

METHODS OF PROPAGATING VARIOUS ROOTSTOCKS.

	Stooling.	Layering.	Hardwood Cuttings.	Root Cuttings.
Apples, M. I, II, IV, VII, IX and XVI	X			
Apples, Shy rooting varieties		X		
Plums, Brompton		X		
Common Mussel		X		X
Common Plum		X		
Marianna			X	
Myrobolan B		X	X	
Quinces, M. A, B, and C	X		X	
Large fruited and other shy rooting varieties		X		
Cherries, Mazzard		X		

Stooling and Layering.—The site should not be on a steep slope, as the form of cultivation assists erosion and some layers may thus become exposed whilst others are buried.

If distinct species of rootstock are planted alongside each other, the risk of admixture when harvesting will be reduced.

It is of some importance to decide at the outset the proportion of each which is to be planted. In planning the new main stoolbeds at East Malling in 1940 this point was considered in relation to past experience of the demands of the trade. The final plan contained the proportions approximately as under:

	Rootstock.		*% Planted.*	
Apple.	Malling	I	10	71
		II	30	
		IV	3	
		VII	3	
		IX	15	
		XVI	10	
Quince.	Malling	A	5	10
		B	5	

	Rootstock.		*% Planted.*	
Plum.	Brompton		5	19
	Common Plum		2	
	Myrobolan B		5	
Cherry.	Mazzard	F12/1	5	
		F12/4	2	

Each rootstock raising project will require its plan to be related to the trade envisaged and only certain kinds included. Though the planning of the East Malling stoolbed may be of interest it should not be used as a rigid guide in the planning of others.

It will be noted that Quince C is not included. Though no other quince rootstock has yet been found to induce such early cropping, Quince C has unfortunately been found especially liable to a leaf spot disease (*Entomosporium*) in the nursery. This requires special spray treatment. Again, in certain seasons, young trees of some varieties exhibit a rough bark trouble which renders them unsaleable from their appearance. As yet no satisfactory solution to these troubles has been found and so this valuable rootstock cannot be recommended unreservedly for commercial handling.

The rows should be set out carefully so that only one spacing is used for stools and one for layers. This saves time in the adjustment of implements. True alignment of rows will ensure equal cultivation of each row, and planting to a line is therefore better than planting to a rough furrow. Implements

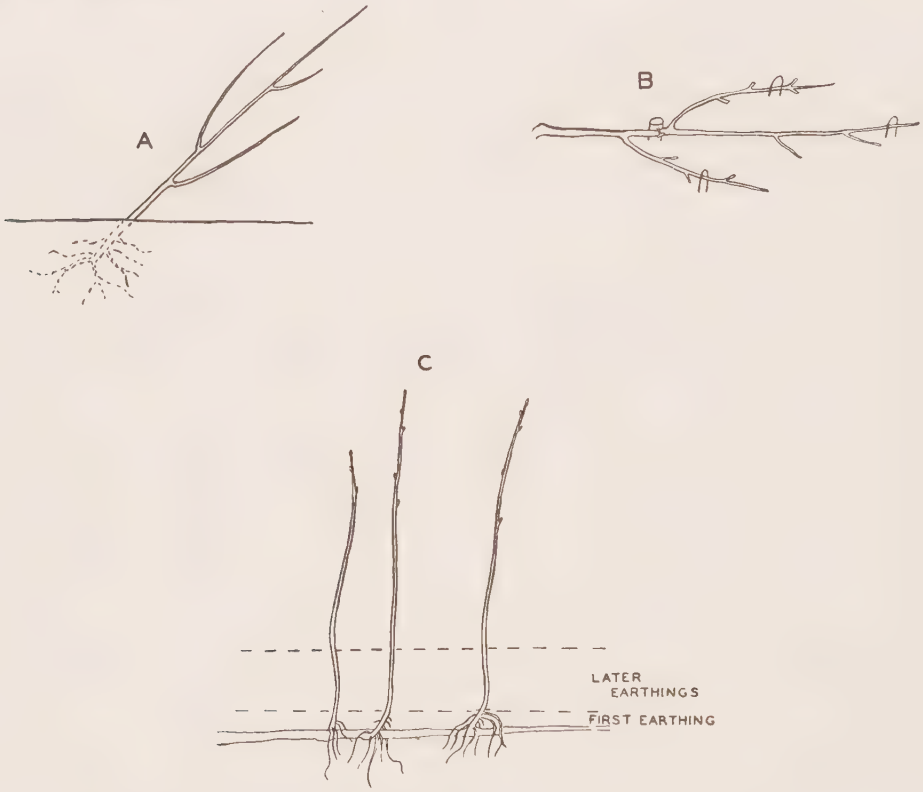

Fig. 1.

should be so built that they fit the rows to be cultivated. This is important in the tracking of spraying machines and trolleys used for removing the crop and cartage of manure. If the vehicles do not fit the rows, cross roads must be left at frequent intervals.

The rows should run north and south to permit the warming of both sides of the earthed rows.

Stool and layer beds are planted whilst the rootstocks are dormant. The ground should be deeply cultivated and clear of perennial weeds. Bindweed (*Convolvulus arvensis*) is a serious weed of stool and layer beds. Heavy dressings of fresh dung are not good, tending to keep the soil puffy and to induce soft rapid growth without corresponding root development. Apart from this the land should have received normally good treatment in its preparations and each year manurial dressings should be given according to growth. Annual potash dressings are called for on most soils.

The bundles of dormant rootstocks may be dipped in 5 per cent. tar oil wash and stood upside down to drain sometime before planting. This will kill any aphis eggs present which might otherwise form colonies on the plants.

The newly planted rootstocks should be hoed frequently during their first season to encourage maximum root growth, and such pests as caterpillar and aphis should be dealt with by spraying. Mildewed shoots on apples should be removed and burnt as soon as seen.

Stooling.—*Establishment.*—The parent rootstocks are planted upright 12 inches apart in rows 3 ft. 6 in. apart to allow sufficient soil for earthing up. Incidentally this distance is similar to that at which rootstocks are lined out for budding and thus in an emergency it is possible to convert budded rootstocks, or worked trees, to stools. The rootstocks should be firmly planted, and cut to within 18 in. of the ground immediately after planting. Shortening to 2 ft. before planting may save time.

Annual Routine.—The rootstocks are allowed to grow for a season unchecked and are then cut to within 1 in. of ground level during the following winter. A large knife should be used and care taken to avoid loosening the stock in the ground. Good secateurs may be used, but a knife cut avoids crushing the bark and consequent destruction of latent buds or their initials.

The tops removed in this process are sometimes used as large hardwood cuttings for further stools. Even with the apple Malling No. IX, a comparatively ready rooter, this has not proved worth while at East Malling, although on well aerated moist soils it might prove economical in times of shortage.

The young stools will produce from one to five shoots in the first season according to variety and local conditions. When most of these shoots are 5 in. high the soil, being previously made friable by cultivators, is drawn up to, and amongst them, by means of a hoe, as in potato earthing, to half the height of the shoots. The space between the rows is cultivated immediately after earthing.

When the shoots have made further growth and are from 8 in. to 10 in. in total height, a mould or ridging plough, set wide, is drawn between the rows so that ridges of soil are placed on either side of the row of stools. These ridges may be some 15 in. apart with the stools between. It is important to *leave the ridges intact* to form the basis of the mound surrounding the stools. The bottom of the trench made by the plough is cultivated and the loosened soil is shovelled out and placed close around and between the shoots by men following the plough. A shovelful of soil placed over the middle of each stool will cause the shoots to bend outwards and this is thought to assist rooting. A further and final earthing is made in July, when the shoots are some 18 in. in total height. It is useless to earth with very dry soil, as this will not stay in ridges, moreover dry soil around the shoots will need very heavy rain to moisten it for the encouragement of roots. If rains are not forthcoming in July it is better to wait even until early August rather than attempt earthing whilst the soil is very dry.

The cultivator should follow the plough, the same day if possible, whilst the soil is moist, and soil shovelled out and placed in close contact with the shoots. The final earthing should bring the soil 6 in. or 8 in. above the *base of the shoots* and 12 in. or so above the bottom of the trench between the rows. Should rain at any time wash the soil down between the shoots in the middle of the stool, and expose them to light, further shovelfuls of soil should be placed in the middle of each stool.

After the final earthing, annual weeds will grow on the earthed soil. These may be cut down and left between the rows finally becoming incorporated with the soil.

In November the soil is forked away from the earthed shoots, all of which are then removed by severing as close as possible to the parent stool. The first crop should be cut off with a knife to avoid injury to the stool, but later crops may be removed with secateurs or large shears of the parrot-bill type. It is important to unearth thoroughly, otherwise it will not be possible to remove the shoots close to the stool, and in a few years this will become so raised by the addition of shoot bases, that it will be impracticable to earth sufficiently deeply.

After the removal of the crop, the parent stool remains exposed until further shoots are produced in the following spring, when the earthing processes are repeated. The earliest opportunity should be taken to apply organic and other manures and to cultivate between the rows to permit the weathering of the soil.

Life of Stoolbeds.—A well managed stoolbed should have a productive life of fifteen years and upwards. Good cultivation, manuring according to growth and cutting off the crop whilst the shoots are still dormant, all help to ensure long life. In some instances, where stools have been allowed to deteriorate, attempts have been made to reinvigorate them by leaving the crop of shoots uncut for a season. But this process encourages pests to become established and the two-year-old shoots are often too coarse for use and have comparatively little extra root.

Layering.—*Establishment.* The technique of layering is designed to bring about the etiolation of the base of the young shoots. Incidentally it has the effect of distributing growth over a larger number of shoots, thus tending to make them more even in size. Layering demands more care and attention than stooling and is far more costly. Therefore, layering is restricted to the propagation of subjects which do not root readily on stools.

The parent rootstocks are planted at an angle of 45° along the row and are usually pointed towards the south. The rows should be 4 ft. 6 in. apart to allow ample soil for earthing. In the row, the rootstocks may be spaced from 18 in. to 30 in. apart. Attention to cultivations in the first season is the same as described for stools.

Annual Routine.—The winter following that in which they were planted the parent layers are pegged down. January-February appears to be better than the autumn because it decreases the risk of frost lifting the pegs and undoing the work. Any weak lateral growths on the stock should be cut back to within half an inch of the main stem. Strong laterals are lightly tipped. Along each row a trench is made about 2 in. deep and wide enough to receive the layer without cramping. Eight inches is generally ample. The parent layer is pegged down flat in this shallow trench so that its tip lies no lower than its base. A little soil should be removed near its base to facilitate bending and avoid an upward bowing of the stock. Pegs may be made from sharpened pieces of wood 10 in. to 12 in. long and having a 2 in. wire nail placed at right angles about an inch from the upper end. A 10 in. length of wood, 3 in. in diameter, will split to form four pegs. Some kinds of green timber will root and grow in the layer bed. This can be avoided by using dry wood. Spanish Chestnut has proved excellent and very rarely strikes root even when green. Willow and poplar have not proved so suitable. Smaller shoots are held in place by 15 in. lengths of ten-gauge wire doubled in the form of a letter U (see Fig. 1B). Any slender shoots not held down by pegs should be cut back close to the ground.

The entire layer is covered with an inch or slightly more of fine soil *before the buds swell.* In April, the young growths will push through the soil with curved growing points exactly in the same way as green peas appear at the soil surface. Before these young shoots have uncurled and expanded their leaves, a further inch of soil should be placed on them. No soil should be added to areas where shoots have not appeared. This process is repeated two or three times during the first few weeks of the growing season. It has the effect of ensuring the etiolation of the first inch or so of the young shoot, and it is from this area that roots will appear later in the season, according to variety. Without this etiolation there is little rooting, and, unless the operator fully appreciates this point layering will not prove successful.

After these initial earthings, and when the shoots have grown 3 in. above the soil, earth should be added as described for stools but at no time should the green shoots be buried more than half their height or rotting may occur.

The following winter the soil is forked away and the rooted shoots are removed. The unrooted shoots are left to be laid and pegged down as before. When all the shoots are rooted, care must be taken to leave at least one shoot every foot or so for layering. After a few years old parts of the layer will die and may be broken out and removed. At each layering the layer should be kept as flat as possible. All laid shoots should be at the same level and no shoot should lie on top of another. Very strong shoots may be half broken at the base without ill effect.

Cuttings.—Probably the most important factor in the rooting of cuttings is the condition of the material used as cuttings. An experienced propagator chooses his material and is, for this reason, termed " green-fingered ". There is some evidence to show that stem cuttings should be taken from somewhat starved plants, or from plants growing in poor soils, to obtain good results. In experiments at East Malling an established hedge of Myrobolan B has provided better cutting material than vigorous plants widely spaced in the nursery. For root cuttings, the age and condition of roots are important. Best results come from one- or two-year-old trees.

The soil in which the cuttings are planted is also very important. It should be moist without being waterlogged. Thus a well aerated soil with a high water table is ideal.

Hardwood Cuttings.—The best results are most frequently obtained by making and planting cuttings in the early autumn.

One-year-old shoots are cut into lengths of 12 in. or 15 in. The actual position of the cut in relation to the buds is of no practical importance and handfuls of cuttings may be cut to the desired length in one operation. The basal parts of shoots give best results. Quince cuttings root better with a " heel ". The cuttings should retain their leaves and therefore should be kept moist until planted. Leafy cuttings should not be tied in bundles, either before or after making, otherwise they will be injured by heating.

The use of a long cutting allows space for budding on the main stem of the rooted cuttings. Short cuttings entail budding on the slender new growth.

The cuttings are planted two-thirds of their length under ground. With long cuttings in heavy soil this makes lifting very difficult and is an added reason for planting in open moist soil.

The cuttings are set 2 in. apart in rows spaced for horse or hand cultivation. Firm planting is important and also frequent hoeing throughout the following season.

The rooted cuttings are lifted when the leaves have dropped. The main roots will be found at the base. Some of the roots higher up may be trimmed off so that the rooted cutting can be planted 5 in. or 6 in. in the soil leaving a similar distance available for budding.

Root Cuttings.—The Common Mussel plum rootstock and some others are fairly readily propagated by root cuttings.

These are usually collected from trees lifted from the nursery during the winter. Such roots,

$\frac{1}{4}$ in. to $\frac{3}{4}$ in. in diameter, are cut into 5-in. lengths and stored in sandy soil until planted. To make sure of planting the cuttings the right way up the end nearest the crown of the plant is cut square across, whilst the other end is cut slantwise.

In early spring, the cuttings are planted upright 2 in. or 3 in. apart in rows which should be spaced for hand cultivation, as root cuttings may be damaged by a horse or tractor. The upper end of the cutting is just covered with soil.

A number of shoots will grow from each cutting and when 1 in. to 2 in. high they are carefully reduced to one. A slender piece of bamboo of pencil length will assist in exposing and separating the young shoots. A further disbudding may be required later in the season.

The rooted cuttings are lifted the following winter. The best will be fit to line out for budding. Smaller plants may be cut back hard and replanted. Any new roots sufficiently large may be used for further root cuttings.

Crop per acre.—Stool and layer beds do not reach full production for four or five years after planting. The crop varies very much according to variety and to local conditions. A return of 10,000 or 12,000 first grade rootstocks per acre may be expected at the end of the second season, rising to 30,000 per acre in the fifth year. In full production, an average crop of 50,000 rootstocks is satisfactory—30,000 fit to line out for budding and 20,000 fit to bed (transplant) for a further season.

Some of the layered plum rootstocks, such as Common Mussel and Brompton, often yield less than 30,000 of first grade stocks per acre, sometimes as low as 15,000 per acre. At the other extreme Quince A has yielded average crops of 60,000 or 70,000 well rooted stocks. There is some variation amongst the apples ; M. IX and M. I root well but after the first five years tend to drop behind M. II in production of shoots. Average crops which have been obtained are shown in Table II.

TABLE II.

AVERAGE CROP OF ROOTSTOCKS PER ACRE PER ANNUM FROM STOOLS AND LAYERS IN FULL PRODUCTION.

Rootstock.		Fit to Bud.	For Bedding.	Total.
Apple	I	30,000	20,000	50,000
	II	35,000	25,000	60,000
	IX	30,000	15,000	45,000
	XVI	35,000	20,000	55,000
Quince	A	70,000	30,000	100,000
	C	50,000	50,000	100,000
Plum	Brompton	23,000	15,000	38,000
	Common Mussel	20,000	15,000	35,000
	Myrobolan B	45,000	10,000	55,000
	Common Plum	35,000	15,000	50,000

The yield from an acre of cuttings depends on the spacing which is largely governed by the method of cultivation. With cuttings at 2 in. apart, in rows spaced for horse cultivation at 2 ft. 3 in., the number planted is rather over 100,000 per acre. With a 50 per cent. success, this means 50,000 rooted, of which some 40,000 may be fit to line out. Whilst with stools and layers both parent and progeny are within the area quoted, in cuttings an additional area is required to accommodate the parent. Where hedges are required and can be made of rootstocks, as is the case with Myrobolan, stem cuttings are a by-product, as are root cuttings trimmed from nursery trees. However when stock trees are maintained solely as a source of cuttings the cost of maintenance must be reckoned against the cuttings and the extra land occupied should not be forgotten. Stock plants, whether in hedges or not, must be kept free of pests and diseases and this consideration may preclude the close planting of apple and pear rootstocks.

Handling the Crop.—At the time of harvesting, the rootstocks in the field are temporarily bundled for ease of handling, and carted to the grading shed. Here, on a bench, they are trimmed, preferably with knives, but usually with secateurs. Side growths are removed entirely from the lower part and to within half an inch of the stem higher up the stock. If all laterals are removed entirely in much feathered varieties, bud-break after planting may be seriously delayed. Very long rootstocks are shortened to about 3 ft. to facilitate handling.

Grading depends mainly on stem diameter at ground level and rooting, but the actual grades vary with the variety. For example, the apple rootstocks do not increase so rapidly in size after planting as do certain plum rootstocks, and where a 5-7 mm. Myrobolan B is safely lined out for budding, an apple rootstock such as M. I needs to be at least 7-10 mm. in diameter to correspond. Rooting cannot be considered apart from size and a medium sized rootstock well rooted is superior to a larger stock

that is poorly rooted. The quality of subsequent growth is important. Thus a rapidly growing rootstock is better for budding than one of similar size that has been slow to get away.

Small rootstocks and poorly rooted larger ones should be bedded for one year before budding to increase in size and in root growth. Large coarse stocks should not be bedded, unless they are required for planting in stoolbeds, but should be discarded. In bedding, the rootstocks are best planted 2 in. apart in rows spaced at 2 ft. 3 in. for horse or tractor cultivation. Another method is to have the rows 12 in. or 15 in. apart with alleys 4 ft. wide every ten feet or so for the passage of sprayers. This latter plan is not suitable on poor soils deficient in moisture, and it is doubtful if the saving in land compensates for the increased cost of hand labour.

If the rootstocks are dipped in a wash of 5 per cent. tar oil before planting, any aphis eggs present will be killed and much early summer spraying made unnecessary.

Bedded rootstocks *v.* one-year layers.—When bedded, a rootstock develops a root system adequate for its needs and can then sustain rather harder conditions than a one-year layer. Thus, more often than not, tree raisers prefer to use bedded stocks, even though they cost more. However, one-year layers, besides costing less initially, have certain distinct advantages if properly handled. If well rooted one-year layers are planted early, under favourable conditions, they grow more rapidly relative to their size, and being one year younger, the bark is thinner and more supple than in bedded stocks, and so better for budding.

Length of time between planting and working.—A rootstock planted in the winter is usually budded in the following summer when in rapid growth, usually between mid-June and mid-August. The bud normally remains dormant until the following spring. The rootstock above the bud having been removed towards the end of the winter, the bud grows out and forms a maiden tree during the growing season. Any rootstocks bearing buds which are found to be dead in the spring following budding, that is some fifteen months after planting the rootstock, are grafted with dormant scions. These scions grow and form maiden trees at the same time as the successful buds.

It is most inadvisable to graft rootstocks the first spring, within a month or two of planting. The resulting trees are usually very weak and fail to keep pace with trees worked at the normal time.

A newly planted rootstock has far more stem than root, and new root growth is very rapid to keep pace with the stem. When these stocks are cut hard in the spring following budding, or at grafting, the roots exceed the stem and the new growth from the bud or graft is very rapid and results in a quickly grown maiden tree.

On the other hand, if a newly planted rootstock is cut hard and grafted at once, the effect of surplus stem is lost, and root growth is comparatively meagre. Furthermore there is no stage at which the hard cutting of an established rootstock can occur and consequently at no time is rapid straight growth encouraged.

Summary.—The practical vegetative propagation of fruit-tree rootstocks by stooling, layering, hardwood- and root-cuttings is described.

The application of the methods is discussed ; production to be expected, and details of handling are also given.

FRUIT PLANTING POLICY WITH SPECIAL REFERENCE TO QUALITY OF MATERIAL*

By R. G. HATTON

On 9th July last the Council of the H.E.A. on the advice of its Fruit Policy Committee, sent a resolution to the Ministry of Agriculture pressing for the compulsory certification of fruit plants, including rootstocks.

Small Fruits.—It is quite clear from the recent fruit-planting orders issued by the Ministry, and by action taken on the advice of the recently formed Agricultural Improvement Council, that the principal of safeguarding the quality of planting material has now been embodied in fruit-planting policy so far as certain fruit plants are concerned. Thus strawberry growers have been permitted to plant only approved runners, and are this season definitely given encouragement to plant only certified ones. In order to make available a sufficient supply of the latter, the Ministry at the request of the Improvement Council have made provision, under the supervision of the Research Stations, for the maintenance of 20 acres of clonal virus-free M.40 Royal Sovereigns and of 20 acres of the best commercial strains of Huxley (Brenda) selected for their vigour and past history, and tested for their low virus content by grafting methods.

There is good prospect that such commercial varieties as Paxton and Tardive de Leopold will be added to the list at an early date and that improved selections of virus " carrier " varieties such as

* Adapted from a paper read at a Conference of the Horticultural Education Association, and published in *Occasional Publication on Scientific Horticulture*, No. 4, June, 1943, pp. 42-46.

Huxley will shortly replace the best commercial strains. These nuclear nurseries under immediate supervision will keep supplying commercial daughter nurseries which will produce " once grown " runners by approved methods for certification. Finally the possibilities of keeping the aphis vectors of strawberry viruses under control with vaporized nicotine should materially help to keep both nuclear and commercial stocks free from invasion.

Again, thanks to the wartime needs, at long last only certified black currant bushes may be planted, so that the grower is no longer free to waste valuable acres in planting up unproductive " reverted " material and to bring virus infection to his neighbours. In conjunction with this Order, a scheme has been set going whereby the Research Stations will maintain a nucleus of healthy bushes of the principal varieties, correctly named, upon which, if need be, the nurseryman or grower can rely for a fresh start. Similarly a clonal nuclear stock of the true loganberry—free from virus disease—is being worked up for the same purpose. Thus the already published results of the English Research Stations are actually to be adopted universally, and not only by the progressive grower, in time of national stress.

As yet far less is known of the virus diseases of the raspberry, and nothing about how they are naturally transmitted in this country. Despite the fact that these raspberry viruses are reputed to travel comparatively slowly, raspberry degeneration has been markedly rapid. Few, if any, of the varieties of thirty years ago are considered commercial to-day and, with the possible exception of Norfolk Giant, most varieties appear to be carriers—symptomless or otherwise—of one of the virus troubles. Finally, raspberries seem much affected by environment and no single variety suits the needs of all localities. In the light of these facts it is not easy to establish a certification scheme, but the Research Stations have been invited to maintain nuclear stocks of vigorous commercial varieties or of new promising seedlings which may take the place of the failing commercial sorts. It rather looks as if " carrier " varieties tolerant of virus diseases may hold the field.

Were they considered sufficiently important, the work on classification and nomenclature of red currants and their comparative freedom from insidious diseases would render certification simple, and it is to be hoped that one day they may be included in an all embracing National scheme. Apart from the problems of American Gooseberry Mildew and of manuring requirements both of which have been satisfactorily solved, the gooseberry industry appears satisfied with the material and information at its disposal.

It is encouraging that the N.F.U. Fruit Committee has passed a resolution giving its support to these measures of control.

So far so good, let us see to it that when peace comes again we do not fall back into the old slipshod methods and allow only our competitors to benefit to the full from the results of years of hard research in this country.

Fruit-tree Rootstocks.—The position with regard to fruit-tree rootstocks is far more complicated and less satisfactory, and it is important that it should be reviewed as briefly as possible.

Wye College Fruit Experiment Station—later to become East Malling Research Station—began in 1912 to collect and examine the samples of vegetatively raised rootstocks (chiefly so-called " Paradise " apple and quince) which the nurserymen of this country and of Western Europe had been invited to send for identification. The preliminary results of these examinations together with full descriptions of the varieties found to be in most common commercial circulation were published in 1917-19 on apple rootstocks, in 1920 on quince rootstocks for pears, and in 1921 on rootstocks for the stone fruits.

Long before it was possible to assess with any certainty the ultimate influence of these varieties upon the scion varieties worked thereon, the fruit-tree nurserymen of this country were quick to see the advantages of having rootstocks 100 per cent. true to name and, through the Horticultural Trades' Association, they approached East Malling in 1917 with the proposal that the Institute should establish nuclear stool and layer beds from which material could be distributed for the establishment of new beds or for identification purposes. Later the nursery trade asked East Malling to maintain some 10 acres of stool beds, the half million rootstocks from which should be distributed annually to members of the Horticultural Trades' Association.

In addition many individual nursery firms who already possessed layer beds invited the author and Mr. Amos to go and examine, identify and rogue them on their own nurseries, and many a long but valuable day was spent in putting commercial layer beds in order and in gaining information as to the common distribution and admixture of rootstocks. This information has more than compensated for the somewhat ungracious claim of certain nurseries that they used " East Malling " rootstocks long before East Malling was founded. Of course they did, though often well mixed up together and misnamed. So far East Malling had not claimed to do more than describe, isolate, propagate and circulate under identification numbers (Apples I to XVI, Quince A to G) and in the case of stone fruits under the commonly agreed names, the commercial varieties which had become so inextricably intermixed.

The first of a series of orchards on identified rootstocks was planted in 1918 at East Malling and the last in 1922 of the main commercial varieties of apple, pear and plum, so that it is now possible to evaluate the various combinations over a period of from 20 to 25 years under our environmental and cultural conditions. Several smaller and less complete trials were planted out and kept under close observation for some years under other environmental conditions. Had the scheme planned and provided for by Sir Frederick Keeble and Captain Wellington, when at the Food Production Department, been carried through, there would have been adequate replications of the central orchard at East Malling on *all* the County Horticultural Plots in England. Then indeed our knowledge of rootstock effect would by now have been much more complete, and agreement about the most valuable varieties much more general.

The rootstock work in England was closely followed on the Continent and detailed publications appeared from the colleagues of Professor Sprenger of Wageningen, Holland, in 1937, and from Professor Maurer of Berlin in 1938. In the Nursery Section of the 12th International Horticultural Congress held in Berlin, August, 1938, the writer summarized the present status of research on rootstock plants and the use of rootstock plants in a brief paper which was subsequently published in the East Malling Research Station Annual Report for 1939 (A23). In this report special mention is made of those rootstocks which have been of outstandingly good or poor performance in the East Malling trials, and it was suggested that international agreement might be reached on the nomenclature and standardization of fruit-tree rootstocks. As a result there was appointed a special Sub-Committee on which the principal European countries interested were represented, with terms of reference to establish common agreement and to formulate regulations which might be accepted by all concerned.

This Sub-Committee, which was to be convened by Professor Maurer of Berlin, has never been summoned, but meanwhile it seems likely that the stool and layer beds of France, Holland, Belgium and probably of Germany itself are now either derelict or destroyed and have largely been replaced by much needed food crops. There should therefore be an unique opportunity when peace and reconstruction come to re-establish the Continental rootstock industry on modern lines on a "clean slate", but it is doubtful if anyone has time to realize the unique national asset which England possesses at this moment.

Actually it was at once flattering and galling to find that the German Reich had, with its usual thoroughness, adopted the English rootstock classification—lock, stock and barrel—had adopted several of its own selections, and had evolved a method of compulsory inspection and declaration whereby the purchaser of every tree could be sure of its component parts. And, needless to say, the plan for regional rootstock trials—shelved in the country which had developed and financed the rootstock researches for twenty-five years—were in full course of centrally controlled development in the Reich! While Holland had not gone quite so far, her nurserymen had formed a voluntary association to run a self-supporting semi-official certification scheme to build up the reputation of their export trade in rootstocks. By lucky chance one of the horticulturists engaged in this work some years ago was recently discovered serving in the Dutch army in England, and is now released to collaborate with East Malling in trying to clear up the position for the dormant International Sub-Committee, and to work out rapid methods of identification which can be placed in the hands of the non-specialist.

The French nurserymen were, like ourselves, free to sell any admixture under any name, and our only hope of protection was the rapid spread of the Colorado Beetle with the resulting restriction of imports from infected areas. Fortunately we have a fruit-tree nursery trade for which there is generally reason to be proud. There are, however, plenty of foolish people always anxious to buy "cheap" trees and not a few misguided ones willing to sell them.

The present position of rootstock supplies in this country is not clear, though the immediate results of the war and of restrictions on commercial planting of top fruit were the complete cessation of demand with a consequent grubbing and burning of some of the most up-to-date stoolbed areas. In this campaign East Malling was advised to and did participate. What was the pre-war acreage of commercial stoolbeds and what it is at present the writer does not know, though probably it was never much above 100 acres.

Before the war several million rootstocks were imported annually into this country despite these home stoolbeds and the half million rootstocks from East Malling. Many of these imported stocks may have been seedling apple, pear, Myrobolan Plum and Mazzard Cherry, but a considerable quantity were vegetatively raised ones.

Although unanimity has not yet and may never be reached with regard to the best rootstocks for every purpose, the present very great diversity of choice, even amongst vegetatively raised rootstocks, renders any certification scheme the job of the all too rare expert, especially in wartime. True, it is now very generally accepted that M. IX (Jaune de Metz), M. II (Doucin), and M. XVI (Ketziner's Ideal) have all a permanent place in the commercial apple industry; there are some who prefer M. I

(Broadleaf) for certain varieties and soils and others who are attracted by the special advantages of M. IV (Holstein) or M. VII. There is the super-standard fan who demands M. XII, and there are even those who claim that their trees have done quite well on stocks proved by careful comparative trials to have poor qualities such as M. III (Holly leaf), M. V (Ameliore), M. VI (Nonsuch), and M. VIII (French). The problem is not so complex with quince, plum or cherry rootstocks because the varieties commercially useful and raised vegetatively are much less numerous, and sometimes even more readily distinguishable. These rootstocks are certainly not more difficult to recognize than varieties of potatoes which are certified, but it needs the long view in wartime to see that, if we do not establish such a scheme for rootstocks now, we shall not be ready to utilize both the unique occasion and our National asset at the crucial moment when peace comes.

A Scheme for Fruit-tree Certification.—Even the German Reich has not dictated what rootstock a nurseryman shall use or what combination a grower shall buy; it merely decrees that the component parts of the tree shall be true to a declared designation. Even if it only be Cox's Orange Pippin on seedling stock, the grower knows that he may be buying a pig in a poke. The intelligent grower will beware of Williams' Bon Chrétien on Quince A, or of Czar on Common Plum stock; he will know the difference between Myrobolan B and seedling Myrobolan.

It is urged that on the lines of other certification schemes all fruit trees should be sold under a descriptive label such as "Cox's Orange Pippin on No. IX", "Cox's Orange Pippin on Seedling", and—in the early stages when stocks are short—even as "Cox's Orange Pippin on unknown stock". Under such a scheme the tree raiser would first apply to have his rootstocks certified, and the bed of stocks planted for budding or grafting would be visited during the pre-working growing season, when the number and variety of stocks would be verified. Any proportion of "rogue" stocks would have to be dug out in the inspector's presence or the plot revisited. The firm in question would then be credited with, say, so many thousand No. II rootstocks. These would subsequently be budded or grafted in certain proportions to known scion varieties. It might be considered necessary to revisit the maiden bed and recertify the scion variety, though our best nursery firms bear a high reputation in this respect. In due course the certifying authority would issue to the firm a numbered certificate for, say, 10,000 Cox's Orange Pippin on No. II. A purchaser would then apply for 5,000 of these and the nurserymen would ask the authorities to send the purchaser a certificate for 5,000, and the nursery the requisite labels bearing the certificate number to be attached to the consignment, and so on until there were no more trees to be sold under that certificate number.

It has been the research worker's job to try and make the tree planter curious about the composition of his tree. Some tree raisers resent this inquisitiveness so that they may sell just what they happen to have. The writer would prefer to pay double for his trees with an individual certificate tied thereon than be given a "cheap" tree. For this tree has a space to fill and a crop to bear and a life maybe of 40 or 50 profitable years to grow and yield and be sprayed, pruned and nourished.

So let us be sure that even our existing knowledge is put to good effect at the earliest possible opportunity, and the planter enabled to buy what he and his advisers deem most suitable for his purpose.

Summary.—The following points are reviewed:

The present position with regard to the certification of small-fruit plants, true to name and substantially free from serious diseases.

The case of tolerant virus "carrier" varieties and the use of approved stocks of these.

The desirability of continuing and gradually extending certification, and the building up and distribution of nuclear stocks.

Proposals for the certification of fruit-tree rootstocks.

The need for the future organization of properly co-ordinated replications, under differing environmental conditions, of important trials.

THE VALUE OF A FRUIT FARM CENSUS*

By T. N. HOBLYN

In a recent number of a leading English horticultural journal there occurred the following paragraph: "The Okanagan district of British Columbia has 24,535 acres planted in orchards. On these there are 1,091,849 apple trees, 150,863 pears, 16,115 plum, 48,367 cherry, 182,957 peach, 93,227 prune, and 45,361 apricot trees. . . ."

This kind of information is available in all the fruit-growing areas in Canada. To a community deriving their livelihood from fruit-growing, and marketing it often at great distances, such statistics are of vital importance, the whole organization depending upon an accurate forecast of the crop in

* Adapted from a paper read at a Conference of the Horticultural Education Association, and published in *Occasional Publication on Scientific Horticulture*, No. 4, June, 1943, pp. 47-51

any one year. In Britain fruit-growing, so long the Cinderella of Agriculture, had developed in the years preceding the war to an important industry, in active competition with other producing areas of the world. Yet all along that industry has been handicapped by a lack of information, and an inability to make any sort of reliable forecast of crops, resulting in haphazard planting and consequent gluts or shortages of one fruit or another.

It has taken a war, however, to bring home the full extent of the handicap ; for, while in peacetime it was mainly the grower who suffered, now the whole nation is affected by the wastage which occurs when no reliable crop forecast is possible and when none of the complicated machinery required for harvesting, preserving and transporting fruit to market can be arranged in advance. The 1940 plum crop will long be remembered as a case in point. Again, the industry is at a loss when machinery, tools, fertilizers, spray materials and containers, to say nothing of labour, are all in short supply. How can it ask for and obtain its fair share of any of these when it can put forward only a not very accurate estimate of the whole acreage planted to fruit trees, a rather better one of the acreage of the various small fruits, but no estimate at all of the actual acreage of individual varieties of apples, pears, plums or cherries ?

Then what of the future ? In the years since the war, the planting of all fruit trees and bushes was at first severely restricted and many of the older worn-out orchards have been grubbed. When, therefore, the inevitable rush comes to replant fruit after the war, what is the grower to plant ? Are all the mistakes of the decade following the last war, when uncontrolled planting led to disaster for so many, to be repeated ?

It is of rather melancholy interest to trace the prices of black currants during the twenty years 1920-39. In the five-year period 1921-25 the average price was something over £90 per ton ; yet, six years later, it had dropped to less than half, reaching a low level of £28 a ton in 1930. It is probably true that improvements in the culture of this fruit and unrestricted imports played a part in this collapse of a profitable crop ; but overplanting was mainly responsible, and if full knowledge had then been available, steps might have been taken in time to avoid disaster. And now, when so much stress is laid on the value of this fruit, the demand cannot be met. The tale of the early culinary varieties of plum and apple might have been exactly similar, had not the artificial conditions of to-day made the large areas planted to these fruits at least temporarily profitable. There was even a question, when the price of Cox's Orange Pippin began to fall in pre-war years, whether this variety was being overplanted ; but, in default of accurate knowledge of the trees then cropping, to say nothing of more recent planting, such discussion was clearly profitless.

But all such information can only be of value if estimates are obtained upon *a solid basis of fact*. For example the plum crop cannot be estimated with any degree of reliability unless the acreage or number of plum trees in bearing is known. The Fruit Farm Surveys have been of great value in finding and disposing of worn-out orchards and in giving a helping hand to growers who need it ; but, with a few exceptions, these have contributed little to the attainment of the required knowledge. What is wanted now is a National Fruit Tree Census, and it is hoped by many that the opportunity has come to carry it out.

What is the best way to do it ? Undoubtedly the most efficient way would be by personal enquiry by the County Officers, properly assisted and with the co-operation of every friend of the industry. Such a course is unfortunately unthinkable in wartime, and it has been asked whether some method could not be devised, whereby a proportion of farms would be visited by a limited number of specially appointed officers. From the proportions of different fruits grown on the farms visited, the numbers for the whole country would then be calculated on the basis of the ordinary Fourth of June returns. This method has two disadvantages. First, there would be no means of assessing the accuracy of the sampling method without considerable preliminary research. Secondly, the various fruit-growing areas in the country differ so greatly that each would have to be sampled separately, whilst, at any rate in the older fruit-growing areas, the proportions of farms visited would probably have to be very large. The only method that remains, therefore, is a form of special return, which the grower himself must complete, giving the items of information required.

PLANS FOR FRUIT CENSUS.—The main difficulty is to design a questionnaire which will give the essential information, without being too complex for the busy grower to complete. Inevitably, before the draft is agreed upon, there will have to be some compromise. However, it is essential that the main framework of the questionnaire and the type of information asked for should be decided at the start and firmly adhered to in any future census. Otherwise, one of the major objects of the survey, the estimation of changes in the production of particular fruits, will be defeated. Thus, at the start, one of the items asked for might be the numbers of apple trees. Later this class might be subdivided into culinary and dessert apples, or even further, giving certain varieties separately ; but, once the number of trees is adopted as the basis, rather than acreage, this basis must be strictly adhered to.

While the actual composition of the proposed census form is still undecided, no detailed description of it can be given. However, the broad principles, upon which it is agreed it should be based, may be described and commented upon.

General Information.—The general information asked for should remain of the type now given in the " Fourth of June " return, but in somewhat greater detail. It should include the total area of the holding and a summary of the areas occupied by fruit on the farm, in which orchards with undercrops of soft fruits or cobnuts would be differentiated from those planted solely with tree fruits and from soft fruits in the open.

Soft Fruits.—Each kind of soft fruit should be listed separately, and subdivided into two classes " as undercrops in orchards " and " in the open ". The area occupied is evidently the only practicable method of assessing them and the acreage in each class would be asked for. The grower would not be expected to calculate the actual area occupied by the soft fruits interplanted in orchards, but merely to give the area of the orchards or plantations in which they are grown. This is probably the wisest way out of a difficulty, since any attempt to estimate the proportion of individual orchards occupied is bound to be largely guess work. Later it would not be very difficult to survey a comparatively small sample of orchards of various ages and with different undercrops, from which an average correction might be calculated for the whole. Where there are two or even more undercrops in the same part of a plantation, as is too often found, it is more difficult to give clear directions, but a solution to this problem would have to be found and the grower told how to proceed in such instances.

It is thought that the subdivision of kinds of fruit into different varieties is not so necessary as with some of the tree fruits. However, where a variety or group of varieties is clearly associated with season, as with Royal Sovereign and Huxley strawberries for example, or with a different system of marketing, as in the case of Leveller gooseberries, which are now the only ones allowed to be sold for dessert, there is a good case for separating them from the remainder.

Tree Fruits.—*Kind and Variety.* -The tree fruits may be classified into seven main groups: dessert apples, culinary apples, pears, vintage fruit (cider apples and perry pears), plums, cherries and nuts. These seven groups should form the basis of the census. Each is, of course, capable of being subdivided almost endlessly. In the chief apple-producing centres of the world almost all the principal varieties have been assessed separately, but usually the number in any particular district is more limited than in this country and the data have been obtained by the personal visits of census officers. Here, for the present, any such subdivision would of necessity have to be reduced to a minimum. Later, further classes might be added. Indeed, once the primary survey is made, the proportions might be estimated by sampling a comparatively small number of holdings. However, it would be clearly desirable to list separately the very few varieties of which a large bulk of fruit could be expected, such as Bramley's Seedling, Cox's Orange Pippin and Worcester Pearmain apples, Conference pears and Victoria plums, and for which special marketing, preserving or storage facilities would be needed. Moreover, the marketing of certain classes of fruits, such as the early cooking apples and plums, has in the past frequently been a problem, and for the sake of the future some estimate of the extent of present-day plantings would be desirable.

Age of Tree.—In crop-forecasting it is obviously essential to differentiate between bearing and non-bearing trees ; and since there are so many differences of opinion as to where the division should be made, it is thought necessary to lay down well defined limits to the age groups decided upon, The majority of apple trees do not bear much over a bushel of fruit until about their eighth year. Plums probably bear earlier, while pears and sweet cherries are usually later. For the sake of simplicity, however, it would probably be wiser to adopt uniform age limits for all fruits. Apart from immediate crop estimates, these categories would be very valuable to the grower in deciding upon what to plant. A very interesting paper was given at the annual meeting of the New York Horticultural Society in 1942, based on just such information as this, in which the changes in the numbers of different kinds of fruit tree in the United States were described. Clear indications were given of the probable increase or decline in production in future years, giving the grower a useful lead in deciding upon his planting programme.

Form of Tree.—In this country there is none of the uniformity of tree form found, for example, in the Dominions or the United States. In English apple orchards are to be found every type of tree from the cordon or the dwarf tree on No. IX rootstock to the giant standard Bramley's Seedling of the Kentish and Wisbech orchards. There is still much controversy about, but little real knowledge of, the relative yields of orchards so planted. For crop estimation, therefore, some subdivision that will differentiate trees of entirely different size or form, is thought necessary, especially if, as will shortly be recommended, number of trees is taken as the basis of assessment.

Number of Trees and Acreage.—Most of the orchards in this country are mixed, the best containing more than one variety of the same kind of fruit, an essential for cross-pollination, and the worst several different kinds of fruit of many different varieties. With such mixed orchards, the estimation

of the acreage occupied by each of their component parts is difficult if not impossible. Further, the actual acreage of any one orchard as a whole is often in doubt. Many growers have no large scale ordnance maps and, while some calculate the area of an orchard to include roads and headlands, others base their estimate on the number of trees and distance of planting alone. Others again rely entirely on hearsay or tradition. This being the case it is agreed that the only comparatively easy method on which to base the census is to count up the number of trees. This is also the easiest basis for crop forecasting and has been generally adopted elsewhere. If a rough estimate of the acreage occupied by each class of fruit could be added, it would be of value to the War Agricultural Executive Committees in allocating machinery, spray materials or manures, but this is not essential either for crop forecasting or for recommendation as to fruit-planting policy.

Crop Estimation.—Having obtained the basic information as to number of trees and area of small fruits in bearing, estimation of production in any one year would be simplified and, of course, the greater the detail in which the census is carried out the simpler it would be. Nevertheless, before the information could be utilized to the full, there would still remain much data to be collected about the yields to be expected from average trees in each class in heavy, medium or light cropping seasons. It is evident, therefore, that, to complete the usefulness of the survey, research by experienced workers would be needed. It is to be hoped that some of the leading growers would be able to co-operate and to give reliable cropping figures. The research stations, of course, have many accurate records of cropping, but these are often criticized as being either too good or too bad for commercial conditions, and can hardly be relied upon entirely. Estimates of the average production of certain experimental apple plantations at East Malling are given in another paper included in this Report.

The information that this census, if carried out, would yield, has been desired by progressive growers for many years, and it is encouraging that, despite the many preoccupations of wartime, the need has at last found expression. Its success would largely depend upon the wholehearted co-operation of those who lead the Industry. Leading fruit-growers, county officers and their assistants, farm surveyors and others could all contribute by propaganda, assistance in filling in the forms, assessing acreages, and the like. The difficulties at the start will be many, but they have not been found insuperable in other countries and should not be so here.

Summary.—The need is stressed for more exact knowledge of the nature and extent of fruit plantings in the country as a basis for the better organization of the Industry, both in wartime and in the period of reconstruction afterwards.

It is thought that the only practicable method of obtaining the information at the present time is by means of a National Fruit Tree Census in the form of a special return to be filled in by every grower.

It is emphasized that the form of the return, though simple at the start, should be standardized. After the initial survey, sampling methods might be devised to elucidate further details.

The broad principles, upon which it is agreed that the construction of the form should be based, are described and commented upon.

THE PRODUCTION OF FRUIT FROM FOUR EXPERIMENTAL APPLE PLANTATIONS AT EAST MALLING, 1920-42

By T. N. HOBLYN

THE need for more precise information concerning the nature and extent of fruit plantings in Great Britain is stressed in a bulletin included in this Annual Report (see p. 93), and a National Fruit Census is suggested as a possible means of providing it. Such a census would be extremely valuable as a foundation for more accurate crop forecasting. Once the preliminary work were accomplished and the numbers of trees in cropping and the areas devoted to small fruits known, however, much further information would be needed before reliable crop estimates could be made. Thus, if the crop reporters should estimate an average or full crop of a particular variety of apple and, from the census, the numbers of bearing trees were known, it would still be necessary to know how much, on the average, fruit trees of that variety were capable of bearing, before any estimate of the tonnage likely to be placed upon the market could be made. At the Research Stations accurate annual records are kept of the cropping of many plantations, and it is with the object of making a contribution to this knowledge that the production history of four experimental apple plantations at East Malling will be described in this paper. It is hoped that, even if the figures given are considered unrepresentative of commercial conditions, they may stimulate fruit-growers to give their own records for the common good of the Industry.

In the proposed Fruit Tree Census, it is suggested that the trees should be divided into two categories for age to separate the trees not yet in cropping from those which have attained maturity. The dividing line has been fixed at the end of the eighth season from planting for all fruits for the sake of simplicity. In the cropping tables which follow, this division has been carried out, even though the trees in these plantations have not generally come into full cropping at that point.

General Considerations.—In examining the cropping of the plantations to be described, certain general considerations must be borne in mind. The four chosen form part of the apple rootstock trials, and in each of them are included trees on all or most of the Malling rootstocks, ranging from dwarf trees on No. IX to very vigorous trees on No. XII. All the different types of tree in any one plantation are, however, planted at the same distances and have received identical cultural treatment since planting.

The layout and cultural treatment in the early years were similar to many commercial plantings made at the same time, namely in the early nineteen-twenties. If the trees seem slow to come into bearing or poor in their subsequent yield by modern standards, it must be remembered that it was upon the carefully recorded history of these very plantations and others like them that much of what is now established orchard practice was founded. Thus, in general, the trees were too closely planted at the start and, after a few years, thinning operations had to be embarked upon. Pruning was then much more severe than is usual to-day; for the "Pruning Plot" at East Malling was only just beginning to show how great may be the delay in cropping due to hard leader-tipping and short spurring of laterals. In that experiment the heavily pruned trees of Lane's Prince Albert and Worcester Pearmain bore their first bushel of fruit up to three years later than those which were "regulated" or entirely unpruned. The plantations to be described were probably treated less severely than was then usual, nevertheless there was undoubtedly some delay in cropping due to this cause.

In manuring and the control of diseases and pests much has been learnt and many problems remain unsolved. If these plantations have not always been ideally treated, the same difficulties have had to be faced and overcome on commercial holdings.

During the period of twenty-three years it was inevitable that the weather should have an adverse effect upon cropping in certain seasons. Only in two, 1935 and 1941, however, when frosts were experienced exceptionally late in May, have the crops of all varieties of apple been severely reduced. In three other seasons, 1926, 1927 and 1938, some varieties were affected, while others set good crops. Thus, in 1926, cold wet weather at blossom time greatly affected the cropping of Lane's Prince Albert, while, in 1927, a frost at the critical green-bud stage caused complete failure of Bramley's Seedling. The weather in these two seasons probably postponed the first substantial crops of these varieties by at least a year. In 1938, the later blossoming varieties only were affected. Such occasional happenings as these must be considered normal in all but exceptionally favoured fruit-growing districts and must of course be allowed for in estimating the average yield over a period.

Method of Estimating Yield.—The records upon which the cropping history of these trees is based are the weighings made annually for individual trees in the plantation as soon as the fruit is picked. They include in most years large drops of marketable size. Between picking and the despatch of the fruit to market considerable wastage generally occurs. Apart from culls, the fruit loses weight naturally, the actual loss of course depending upon the time which elapses. The total wastage from all causes has been estimated to average about 20%, and accordingly, in the following tables, this amount has been deducted from the field weights.

1. Two Acre Plantation of Lane's Prince Albert interplanted with Grenadier.

Most of the trees in this plantation (known as Plot 11) were planted out in January 1920 as maidens. The distance of planting was 15 feet square (193 trees to the acre) and remains so at the time of writing. Three-quarters of the trees are bush Lane's Prince Albert, which were 23 years old at the end of 1942.* The remainder of the trees are half-standard Grenadier, mostly on the more vigorous rootstocks. These were planted as two-year feathered trees in January 1923 and are thus three years younger.

Cultural Treatment.—For the first nine years of its life the plantation had black currants as an undercrop. Clean cultivation has been practised since planting, except for cover crops in one or two seasons. By clean cultivation is meant the usual practice of keeping the land clean in spring and early summer, but letting the weeds grow in the late summer and autumn. The plantation received generous manurial treatment, in the early years mainly in organic form, and later in the form of sulphate of ammonia and sulphate of potash. On the Lane's Prince Albert the leaders were tipped and laterals long-spurred annually and, while this treatment was probably more lenient than was usual twenty years ago, it undoubtedly delayed cropping. The process of tipping and spurring has been continued throughout the life of the trees, while in recent years the complex spur system which

* All ages of trees given in this paper are reckoned from the date of planting.

resulted was drastically reduced. In 1938, when parts of the plantation became somewhat crowded, it was planned to remove part of the Lane's as it became necessary. In pruning, therefore, the trees destined for removal were cut back to allow the others to develop. It has not yet been necessary to remove any trees. The half-standard Grenadiers were from the start also tipped and long-spurred, save for one season towards the end of the period in which the leaders were left uncut. The trees have received the normal spray treatment for Lane's. For a short period red spider was found difficult to control, while in some years apple blossom weevil has been severe ; otherwise diseases and pests have not materially affected the growth or cropping of the trees. Fruit thinning has been carried out annually upon a few trees, but the bulk of them have been thinned only in a few years of very heavy crop.

Cropping.—Table I gives the cropping history of this plantation. Since the two varieties are not the same age, it has been necessary to divide the table into three parts, (i) when neither variety had reached maturity, (ii) when the Lane's Prince Albert were over eight years old, but the Grenadier were not, (iii) when both varieties were nine years old or more. Yields are given in bushels both per acre and per tree.

TABLE I.

AVERAGE YEARLY PRODUCTION OF A PLANTATION OF LANE'S PRINCE ALBERT AND GRENADIER APPLE OVER A TWENTY-THREE YEAR PERIOD IN BUSHELS PER ACRE AND PER TREE.

Variety.	Number of trees per acre.	1920-27. (i) First 8 years. Per Acre.	Per Tree.	1928-30. (ii) 9th to 11th years. Per Acre.	Per Tree.	1931-42. (iii) 12th to 23rd years. Per Acre.	Per Tree.
Lane's Prince Albert	144	14	0·1	227	1·5	320	2·1
Grenadier	48	—	—	14	0·3	60	1·3
Total	192	14		241		380	

The crop of the first eight seasons from the establishment of the plantation was negligible, except for the few trees on No. IX rootstock. Actually, the Lane's did not produce their first full crop until the tenth season, when they gave an average of $2\frac{1}{4}$ bushels per tree. In the previous year they had averaged half a bushel. The Grenadier were slower to come into cropping, giving half a bushel in their eighth and ninth seasons, but not producing more than a bushel per tree until the eleventh season. The average crop per tree of Lane's over the fifteen-year period since they were of bearing age has been about two bushels per tree. The heaviest crop of $4\frac{3}{4}$ bushels per tree was harvested in 1936, in which season the crop of the whole plantation reached its highest level of 800 bushels per acre. This, however, followed a year of complete failure (1935) owing to frost, while the same ill chance brought the acreage yield down to 73 bushels in 1941.

The Grenadier have never borne very heavy crops, partly because at least one-third of the trees are on rootstocks now known to be unsuitable for working as half-standards. The average yield has been one and a quarter bushels per tree and the highest two and three-quarters in 1942. The average yield of the whole plantation from the twelfth to the twenty-third season was 380 bushels per acre.

2. One and a quarter Acre Plantation of Bramley's Seedling.

This plantation, known as Plot 13, was also planted in January 1920, the trees all being maidens. In the original plant, the Bramley's Seedling were interplanted alternately with Worcester Pearmain at 15 feet square, and both varieties included trees on the whole range of Malling rootstocks. It is worth remembering that this distance was then considered by growers unduly far apart for trees on " Paradise ". Nevertheless, it was only possible to maintain this plant for thirteen years, by which time the trees were so overcrowded that it became necessary to grub all the Worcesters. About this time the plantation was put down to grass in an effort to check the growth of the Bramley's. It was soon found, however, that if the growth were checked, the general health and productivity of the trees would also suffer, so it was decided to reduce the number of trees by half again. During the period after the removal of the Worcester Pearmains, it became clear that it was inadvisable to leave solid blocks of Bramley's Seedling without a pollinator. So one-quarter of the trees due for removal were severely cut up instead and frameworked to Grenadier to provide for this need. Thus, at the present time, the plant is Bramley's Seedling at 30 feet square, 48 trees to the acre, plus one Grenadier to every four, or twelve trees to the acre.

Cultural Treatment.—Until 1928, the trees were interplanted with black currants in the rows and raspberries between the rows, the land being kept clean cultivated and the manurial treatment

generous, particularly with respect to mainly nitrogenous organic manures. After the removal of the soft fruits, clean cultivation was maintained until the spring of 1932, when, as indicated above, the plantation was laid down to grass. For the next five years, the plantation was included in a series of trials of the effects of nitrogenous manuring on trees under grass. Although, for about two seasons, the treatments given materially affected the quality of the fruit, they were not continued long enough to affect cropping appreciably. However, in recent years, it is probable that higher nitrogen dressings would have improved both regularity of bearing and the size of the fruit. Potash requirements have been maintained by regular dressings. In the winter 1941–42 the grass on half of the plantation was ploughed in and this part has been kept clean cultivated since. The Bramley's Seedling were tipped for the first two or three years only, while the trees were being shaped ; since then the trees have been regulated, superfluous and crossing branches being removed as necessary. The Worcester Pearmains were at first tipped and long-spurred in the same way as the Lane's described above, but this treatment was soon modified, dards on the outside of the trees being left full length and the amount of leader tipping reduced and in some years omitted altogether. Nevertheless they were slower than the Bramley's to come into full bearing. The normal spray programme has been carried out throughout and, except for an outbreak of canker in the Worcester Pearmains in 1926, diseases and pests have not reduced cropping.

Cropping.—The average yearly production of apples on this plantation is given in Table II, which is divided into four periods : (i) the first eight years, 1920-27, when neither variety was in bearing ; (ii) the ninth to the thirteenth year, when both varieties were cropping ; (iii) the fourteenth to twentieth year, during which there was a solid plant of Bramley's Seedling at 96 trees to the acre ; (iv) the three years since the Bramley's were again thinned and a proportion of them frameworked to Grenadier.

TABLE II.

AVERAGE ANNUAL YIELD OF PLANTATION OF BRAMLEY'S SEEDLING OVER A TWENTY-THREE YEAR PERIOD IN BUSHELS PER ACRE AND PER TREE.

Period since Planting	1920-27. (i) 1-8 years.		1928-32. (ii) 9-13 years.		1933-39. (iii) 14-20 years.		1940-42. (iv) 21-23 years.	
Number of Trees to the Acre	96 Bramley. 96 Worcester.		96 Bramley. 96 Worcester.		96 Bramley.		48 Bramley. 12 Grenadier.	
Census Category ..	1-8 years : 100-500 trees per acre.		Over 8 years : 100-500 per acre.		Over 8 years : under 100 per acre.		Over 8 years : under 100 per acre.	
Yield of :	Per Acre.	**Per Tree.**	Per Acre.	**Per Tree.**	Per Acre.	**Per Tree.**	Per Acre.	**Per Tree.**
Bramley's Seedling	4	**0·05**	207	**2**	351	**3·5**	255	**5·25**
Worcester Pearmain	8	**0·1**	90	**1**	—	—	—	—
Grenadier	—	—	—	—	—	—	30	**2·5**
Total	12		297		351		285	

During the first period the Bramley's Seedling crop was negligible, while the Worcester Pearmains only gave half a bushel to the tree in the eighth season. The first real crop of Bramley's Seedling, of one and a half bushels per tree, was harvested in the ninth season, but the Worcester Pearmains did not reach a bushel to the tree until the next year. Over the whole of this second period, of five years, the Bramley's Seedling averaged two bushels per tree and the Worcester Pearmain one bushel, the total crop being at the rate of about 300 bushels to the acre. Towards the end of this period, the Worcester Pearmains were undoubtedly suffering from the competition of the stronger growing Bramley's Seedling ; and, while this reduced the crops, the continuous clean cultivation had a bad effect upon fruit colour.

In the next seven years, 1933-39, the Bramley's Seedling averaged $3\frac{1}{2}$ bushels per tree, or about 350 bushels to the acre. Over most of the period the variety was highly biennial. In 1938, however, weather conditions, which were also possibly responsible for poor pollination, greatly reduced fruiting in an " on " year ; after this good crops were produced in two consecutive years. The highest yield was $8\frac{1}{4}$ bushels per tree, or 790 bushels per acre, in 1936. In this year the heaviest crop ever harvested at East Malling from a single tree—19 bushels from a tree on No. XII rootstock—was obtained. The last period of three years only is not long enough to give a picture of the potentialities of the plantation in its final form. The annual average of $5\frac{1}{4}$ bushels per tree includes two " on " and one " off " year. The crop of 8 bushels per tree in 1942 does not equal that of 1936 and does not yet compensate for the

loss of the trees thinned out. The average yield of the Bramley's from the ninth to the twenty-third season was $3\frac{1}{2}$ bushels per tree. The Grenadier pollinators produced $2\frac{1}{2}$ bushels per tree in the third year after frameworking and $5\frac{1}{2}$ bushels in the fourth year, and thus demonstrate once more the rapidity with which a variety may be changed and brought back into cropping by the use of this method.

3. One and a quarter Acre Plantation of Worcester Pearmain.

This plantation is adjacent to that just described and, being planted at the same time, January 1920, was originally very similar in design, the varieties, Bramley's Seedling and Worcester Pearmain, rootstocks and planting distances being the same. This plant was maintained until 1934, two years longer than its neighbour, when once again overcrowding dictated the removal of half the trees. This time, however, it was the Bramley's Seedlings that were removed. Since Worcester Pearmain is an upright and considerably weaker growing variety than Bramley's Seedling, it was possible to replace the latter with smaller trees. When, therefore, the thinning of another plantation made available some 15-year-old trees of Worcester Pearmain on rootstocks of intermediate vigour, they were transplanted to this plantation to fill in most of the gaps. A year later sufficient 22-year-old James Grieve on mixed " Paradise " rootstocks, rather more than half of which had been identified as M. V, were added to give one pollinator in ten trees. The final plant is therefore Worcester Pearmain at 15 feet square with James Grieve as pollinator.

Cultural Treatment.—For the first nine years this plantation, like its neighbour, had black currants and raspberries interplanted between the trees, and, for the first ten years, cultivations and manuring were the same. In April 1930, the eleventh season, the trees were laid down to grass. The effect of this without nitrogenous manuring was to check the growth of the trees and reduce fruit size severely, and, three years after grassing down, experiments in nitrogenous manuring were started to find a remedy. As these resulted in increased growth, the Bramley's had to be removed, but the experiments were continued for a further short period upon the Worcesters. The object of these experiments throughout has been to maintain the trees in a healthy condition without spoiling the colour and quality of the fruit, by the judicious use of grass cover and artificial nitrogen fertilizers. The plantation remained wholly under grass until 1941, by which time it had become clear that it was not possible to maintain sufficient growth without very heavy applications of nitrogen. Half was then ploughed in and is now clean cultivated.

The pruning of the Worcester Pearmains has been the same as in the neighbouring plantation, except that half of the trees were left entirely unpruned for the first eight years.

Cropping.—The average annual yields of the plantation are set out in Table III. Again it is necessary to divide them up into four periods : (i) the first eight years ; (ii) the ninth to fifteenth years, when Worcester Pearmain and Bramley's Seedling were both cropping ; (iii) a short period of two years, when the permanent Worcester Pearmains were alone in the plantation ; (iv) the eighteenth to twenty-third years, when the plantation was once more fully planted up.

The first two periods need little comment, since the yields were essentially the same as those given in Table II for the adjoining plantation. The early crops here were rather higher, owing to the absence of pruning on half the trees. The Worcester Pearmain in the unpruned part of the

Table III.

Average Annual Cropping of a Plantation of Worcester Pearmain in bushels per acre and per tree.

Period since planting	1920-27. (i) 1-8 years.		1928-34. (ii) 9-15 years.		1935-36. (iii) 16-17 years.		1937-42. (iv) 18-23 years.	
Number of Trees per Acre	96 Worcester. 96 Bramley.		96 Worcester. 96 Bramley.		96 Worcester.		96 Permanent Worcester. 76 Transplanted Worcester. 20 James Grieve.	
Yield.	Per Acre.	Per Tree.	Per Acre.	Per Tree.	Per Acre.	Per Tree.	Per Acre.	Per Tree.
Permanent Worcester	11	0·1	111	1·2	171	1·8	251	2·6
Transplanted Worcester	—	—	—	—	—	—	71	0·9
Bramley's Seedling	6	0·06	252	2·6	—	—	—	—
James Grieve	—	—	—	—	—	—	11	0·6
Total	17		363		171		333	

plantation produced their first crop of a bushel per tree a year earlier than on that part which was pruned normally ; but the Bramley's Seedling all came in together in the ninth year, the difference in treatment being, of course, much smaller.

The third period, of only two seasons, includes the frost year 1935. While Worcester Pearmain was not so severely affected as most varieties, the crop in this year was still very small. During the last period of six years, the cropping of the permanent Worcesters was very regular, averaging 2·6 bushels per tree. The highest yield, in 1939, was just over 4 bushels, a yield which would have returned 800 bushels per acre if the whole plantation had been planted alike. The lowest yield was a bushel and a half per tree in 1941, in which year this variety again showed its ability to withstand frost. The average crop per tree of the permanent Worcesters from the ninth to the twenty-third season was 1·8 bushels, or 350 bushels per acre had there been a full plant all the time.

The transplanted trees have not cropped very well, averaging just under a bushel per tree. It must be remembered, however, that these trees were planted in the positions occupied by the Bramley's until two years previously and could not have been expected to recover very quickly. In fresh ground the result might have been better.

4. One and a half Acre Plantation of Bush Cox's Orange Pippin with a Pollinator.

This plantation (known as Plot 32) was established in the spring of 1922, the trees being planted as maidens. In its original form, it contained the varieties Cox's Orange Pippin and Stirling Castle, again on a range of Malling rootstocks. The two varieties were planted at 12 feet square in alternate rows, but there was a slightly larger proportion of Cox's Orange Pippin.

Twenty years ago, many unsolved problems still confronted the grower of Cox's Orange Pippin, which was then widely regarded as a variety only to be grown successfully in particularly suitable locations.

Of these problems, the control of Apple Scab was of such urgent importance that, in 1926, this plantation was devoted to spraying trials for the control of this disease. These trials have been continued very nearly up to the present day, and it is largely upon the results achieved that the modern recommendations for spraying this variety are based. Such experiments over a long period of years, starting as they did with little or no information, could not be expected to yield results without loss of crop and damage to the trees on at least part of the plantation. The first casualty was the pollinator variety ; for it was soon found that, with respect to fungicidal spraying, the two varieties were incompatible. Stirling Castle was discovered to be sulphur shy, while alternative copper-containing sprays, such as Bordeaux mixture, caused a reduction in fruit set, fruit drop and severe russeting in Cox's Orange Pippin. Thus, by the end of 1931, it was clear that Stirling Castle would have to be replaced, and the trees were gradually reworked to Worcester Pearmain. This process was carried out over a period of four years to avoid leaving the Cox's Orange Pippin altogether without pollination. At the same time, the occasion was used to try out some of the methods of frameworking, then new to this country. On many of the trees, however, the older method of topworking was used for comparison, and the return to cropping was on the whole slow. Thus, at the present time, the plantation is a 12 foot square plant containing 168 Cox's Orange Pippin and 134 Worcester Pearmain to the acre.

Cultural Treatment.—One year after planting, the trees were interplanted with raspberries between the rows and red currants in the tree rows. The raspberries were removed in the autumn of 1929, when the trees were eight years old, but it was found possible to retain the red currants until 1937. Except for cover crops in two or three seasons, the plantation has been clean cultivated throughout its history, while the manuring has been similar to other apple plantations and no marked deficiency has been allowed to develop. A fairly heavy dressing of compost was applied in 1938. Until 1938, the seventeenth year, trees on all rootstocks were leader-tipped and long-spurred alike. In that year, the trees on the more vigorous rootstocks were pruned more lightly, leader-tipping being omitted altogether for one season, and some laterals on the outside of the tree left full length. In the winter of 1941-42, fairly severe shortening of the longer complex spurs was carried out. The Worcester Pearmains have been only lightly pruned to ensure a plentiful supply of blossom and hasten the return to cropping. As already indicated, the use of the plantation for experiments in the control of Apple Scab has undoubtedly led to reductions in cropping in certain years due to fruit drop, while damage to foliage must also have had an effect on cropping in subsequent seasons. This was most evident in Stirling Castle, many of the trees being crippled. In recent years Red Spider and the use of petroleum washes for its control have provided further problems and, in at least three seasons, the foliage of the Cox's Orange Pippin has been damaged, either directly by the petroleum spraying itself, or by the pre-blossom application of lime-sulphur following it too closely. In the years prior to reworking, the Stirling Castle had severe attacks of Apple Canker, some 25% of the trees developing large cankers in the stem and crotch. Since that time, the spread has been to some extent kept in check by cutting out affected parts and bridge-grafting or inarching where necessary. Nevertheless some of the trees

reworked to Worcester have been lost and others severely checked. Apart from these, diseases or pests have not seriously interfered with cropping.

Cropping.—The average yearly production of apples is given in Table IV, which is again divided into four periods : (i) the first eight years, 1922-29; (ii) the ninth and tenth years, when both Cox and Stirling Castle were of bearing age ; (iii) the interim period of four years, while the reworking was in progress ; (iv) the fifteenth to twenty-first seasons, when both Cox and Worcester were in full cropping.

While this plantation has been rich in experimental results, its yield of fruit has not been heavy. Nevertheless, if the problems here investigated were a reflection of those in fruit-growers' plantations, these yields go far to explain why Cox's Orange Pippin has remained an expensive variety. During the first eleven years, the only substantial crop of this variety was one of twelve pounds per tree in the ninth season ; and it was not until the twelfth and thirteenth seasons that crops of more than a bushel were gathered. Since the fifteenth year, the variety has averaged a bushel a tree per annum, the maximum being just under 2 bushels in 1939 and 1942. Stirling Castle never really gave a crop of commercial value, the best being fifteen pounds a tree in the ninth season. Since they returned to cropping, the trees reworked with Worcester Pearmain have averaged only half a bushel to the tree, the highest crop being a bushel and a quarter in 1939. The high proportion of very small trees is largely responsible for the low average while, since pollination is their primary object, some of the larger trees have had to be cut back severely to allow the Cox's Orange space to develop.

The total production of the plantation, which averaged 164 bushels to the acre during the last seven years, reached its maximum to date of 317 bushels in 1939.

TABLE IV.

AVERAGE ANNUAL YIELD OF PLANTATION OF COX'S ORANGE PIPPIN OVER A TWENTY-ONE YEAR PERIOD, IN BUSHELS PER ACRE AND PER TREE.

Period since planting	1922-29. (i) 1-8 years.		1930-31. (ii) 9th & 10th years.		1932-35. (iii) 11th-14th years.		1936-42. (iv) 15th-21st years.	
Number of Trees to the Acre	168 Cox. 134 Stirling.		168 Cox. 134 Stirling.		168 Cox. 134 Stirling T/W Worcester.		168 Cox. 134 Worcester.	
Yield of :	Per Acre.	Per Tree.	Per Acre.	Per Tree.	Per Acre.	Per Tree.	Per Acre.	Per Tree.
Cox's Orange Pippin	3	0	30	0·2	98	0·8	186	1·1
Stirling Castle ..	4	0	28	0·2	—	—	—	—
Worcester Pearmain	—	—	—	—	—	—	71	0·5
Total	7		58		98		257	

Discussion.—From the crop records of the four more important varieties of apple set out above, it is possible to construct some sort of picture of the capabilities of plantations such as these. Under the system of pruning in common use twenty years ago, the crop produced during the first eight years was negligible, except for trees on No. IX, and it was not until the ninth or tenth season that the trees yielded a first crop of a bushel of apples to a tree. To-day, with lighter pruning and favourable seasons, a plantation of Worcester Pearmain or Lane's Prince Albert and even Cox's Orange Pippin, all upon, say, Malling Nos. I or II rootstocks, may come into bearing earlier, but it seems doubtful whether Bramley's Seedling can be expected to bear before the eighth season at the earliest. Once the plantations were in bearing, the three first described have averaged between 300 and 350 bushels of apples per acre, irrespective of variety or planting distance. These returns may appear good, but it must be remembered that these crops must be spread over the whole life of the plantations, including the eight or nine years prior to maturity.

The fruiting of Cox's Orange Pippin has been lighter, but the adverse effect of the experimental treatments in the particular plantation described has been at any rate partly responsible for the result.

It will be of much interest to compare these returns with growers' own experiences.

Summary.—The cropping history of four experimental plantations, over a period of some twenty years, is described. The four principal varieties included in them are Lane's Prince Albert, Bramley's Seedling, Worcester Pearmain and Cox's Orange Pippin. Except for trees on M. IX rootstock, the yield in the first eight years from planting was negligible. When mature, the yield per tree varied for different varieties but, except for Cox's Orange Pippin, the yields per acre were not dissimilar.

PLANTS AND THEIR WATER SUPPLY*

By W. S. ROGERS

I WONDER if you have ever realized that a fair-sized cabbage needs about 40 gallons of water in the course of its life. Forty gallons—perhaps that surprises you. Of course, water makes up at least four-fifths of the weight of most vegetables, and it plays a vital part in all the wonderful processes of plant growth, besides keeping the young cells firm. But by far the largest amount of water is evaporated from the *leaves* by the process called transpiration. So that is how your potatoes and cabbages, for instances, use *over 50 gallons* of water for every pound of dry matter which they produce. Some plants, such as peas and beans, need even more.

Now this water is absorbed by the plants' roots from the *soil*, which acts as a reservoir for the *rainfall*, and in our erratic climate this store of available water is quite likely to run short and limit the amount of crop which we produce. Growth is checked long before the plant wilts; and as a matter of fact quite severe droughts occur now and again in most parts of the country—even in Manchester. So I am sure you will agree that it is important as well as interesting to understand how the water is stored in the soil and how the plant gets and uses it. Indeed, arranging matters so that we get the greatest possible crop from the water available is a real form of National Service.

At East Malling Research Station we have been studying the use of water by plants, by means of special instruments which record the soil moisture. The information gained from these instruments, together with the work of other scientists, can, I think, help us to make the most of the natural water supply and of any extra water which we apply artificially.

One basic fact is this: The old idea that water moves freely from moist to drier soil by capillary action—like oil in a lamp wick—is not quite right. When the soil is really wet, water *will* move about in it fairly freely; but, when the soil begins to dry, water movement is greatly restricted; and in really dry soil there is hardly any water movement. You can check this for yourself by digging a hole in, say, grassland when a moderate rain has followed a long dry period. You will find that only the top few inches of soil are moistened, and below this the soil is quite dry. At some distance below this again we know a water table exists. Now, if water movement by capillary action were rapid, the moisture would obviously be distributed quickly and evenly through the soil—but this actually does not happen, under dry conditions.

From this we can draw several useful conclusions. First, water more than a few inches away from the plant roots is not available to the plant under dry soil conditions. Therefore we must ensure that the plant roots can extend through a large volume of the soil so as to tap a good water supply. Plant roots go much deeper and wider than you might imagine, if conditions are suitable. We have excavated many root systems and seen it, so this is where deep cultivation may be most valuable, and, of course, choice of naturally deep fertile soils. *Drainage* also helps to extend the depth available to roots, in soils which would otherwise get waterlogged in wet periods. In fact, if you can extend the available soil depth, it is like extending the height of a factory—the productive capacity is increased on the same area of ground.

Does hoeing conserve water? By removing weeds, yes; but *not* by making a loose crumbly surface. The top inch or so of soil dries quickly by evaporation, whether it is loose or compact, and our experiments show that such dry soil layers, either loose or compact, form equal barriers to water loss. *Weed control*, however, is most important, for weeds such as grass use large amounts of water. For example, we found drought conditions in a grass orchard three weeks earlier than in a clean cultivated orchard. But weed control by any method such as hand pulling, or the new spraying methods for certain crops, saves as much *water* as hoeing.

Stirring the surface-soil certainly increases aeration and bacterial activity which stimulates plant growth by making available foods stored up in the organic matter of the soil. But excessive cultivation can be merely wasteful of this important store of plant food.

Humus greatly increases the water-holding capacity of the soil, and experiments have also shown that plants make more growth, for a given amount of water, on fertile and well manured soil than on poor soil, hence application of well balanced amounts of both organic and inorganic manures is important.

Another point is that *shelter* from drying winds conserves water, by reducing transpiration, so windbreak fences or hedges may be worth providing in windy situations. But remember that the roots of hedges extend and draw water from several feet on either side.

Finally there is *watering*. This is well worth considering in dry periods where a suitable water supply is available—especially in the east of England. Artificial irrigation is already widely used

* From a talk broadcast in the B.B.C. Home Service, June 5th, 1942.

by commercial vegetable growers, and at East Malling we have greatly increased various fruit crops by watering in dry periods. The old idea that if you begin watering you have to keep on does not apply if you do it thoroughly. But it is important to water in the right way.

For efficient irrigation the ground should be saturated to the full depth of the roots, and not beyond. You will get a good idea of this if you imagine that wetting the soil is like filling a cup of tea, but the other way round—in filling a tea-cup the bottom half must be filled before the top half; but in remoistening the soil block the top inch must be almost saturated before the second inch gets any, the second before the third, and so on. Therefore very light applications of water are wasteful, for they merely wet the surface without reaching the roots, and are quickly lost by evaporation. In fact they are rather like handing round the tea at a party in spoonfuls instead of cupfuls. Most of it would be wasted.

Of course, the larger the plant, the more water it needs. We find that for medium-sized plants (such as, for instance, strawberries), on our sandy loam, about 2 to 4 gallons of water per square yard is a suitable application. This should last the plants for a week to a fortnight. Four and two-thirds gallons per square yard is equivalent to one inch of rain, and this will usually penetrate to a depth of about one foot (depending on the nature and wetness of the soil).

The right *time* for watering, to maintain best growth, is well before the plant shows signs of wilting. In the absence of instruments you must judge this by experience. Under East Malling conditions, it is usually after about a fortnight's drought in summer. But it varies with different plants and soils. Tomatoes provide a good example of the danger of leaving watering too late, for if watered too late the fruits split, by rapid swelling after being checked.

We find that most efficient and economical water distribution is given by overhead irrigation methods, by sprinkler, fine hose, or oscillating pipe-line. The furrow method is useful, too, where you have got plenty of water under low pressure, as from a mill dam. If you use the humble water-can, you can save time by making shallow earth basins round the plants, to hold the water in ; but the different methods cannot be discussed here in detail. The important point is that one good soaking is better than many light sprinklings.

There are thus six points—weed control, drainage, extending the root range, manuring, shelter, and reasonable watering—which are all ways of controlling the plant's water supply for our own advantage.

Summary.—Water can be a limiting factor in plant growth, even in England. The movement of water in soil is described. Water can be conserved by weed control, drainage, extending the root range, suitable manuring, and shelter from winds. Economical methods of artificial irrigation are outlined.

SOME FRUIT DISEASES SEEN ON SURVEY IN KENT

By H. B. S. MONTGOMERY and M. H. MOORE

On some farms visited, and not always the biggest, the growers were fully aware of the annual toll of crops taken by disease. It was not surprising that such growers knew what to do about it and were doing it to the best of their ability, handicapped though they were like everyone else by the shortage of skilled labour. On far too many farms, however, some diseases were found of which the grower knew nothing ; he was often unaware that they were there. It is the purpose of this article to draw attention to some of the diseases most frequently seen, and to suggest remedies.

Apart from ignorance of the diseases, however, two outstanding findings of the survey cannot be too strongly emphasized : the overcrowding of trees and lack of pruning, and inefficient spraying machinery.

Diseases flourish where trees cannot get enough light and air. Spraying is handicapped from the outset in such circumstances, more particularly where the machine is too small to do the work properly and in good time even if the trees were ideally spaced and pruned. Machine power can offset lack of man power to some extent.

Copper-lime dust was being used by some growers in preference to wet spraying. An acreage can be covered much more rapidly by dusting than by spraying, and with a shortage of labour dusting has a strong claim to consideration. It is not as effective as wet spraying, but it is better than doing nothing. That the dust tends to drift over a wide area is a drawback, because varieties likely to be damaged cannot easily be omitted from treatment.

Apple Scab.—So much information on this disease and its control has been made available to growers by articles, films, spray calendars, lectures, etc., that it can be dismissed here with a reminder of one all-important point—it is the lime-sulphur sprays given before blossom that are usually most

effective because the new leaves are thus protected early, before the disease gets going. These sprays need not be unduly strong and harmful to foliage ; correct timing of applications is better, and 2½ per cent. at green-cluster (green-bud), followed by 2 per cent. at pink-bud, are strong enough. Most varieties that require further spraying will tolerate 1 per cent. at 80 per cent. petal-fall.

Pear Scab.—Again, most growers are already familiar with the spray programme for pears. Pears are not nearly so shy of copper as apples are, and any fruit-russeting caused is not such a drawback ; the copper spray, moreover, gives better control of Pear Scab than the fairly weak lime-sulphur (1 per cent.) necessary for safety on most pear varieties after blossom. One drawback of a copper spray used *before* blossom, on pears as well as apples, is the risk of subsequent fruit cracking, which is far more serious than russeting. The earlier the skin of the fruit is damaged—and it can be damaged by spraying before blossom—the more risk is there of cracking rather than merely russeting the fruit. Lime-sulphur (2½ per cent.) is as good as Bordeaux before blossom, and is more easily prepared, so that lime-sulphur before blossom and a copper spray afterwards is sound policy. Where apples and pears are interplanted it is best to rely on lime-sulphur for both.

Apple Canker.—Some areas of Kent suffer very severely from this disease and growers are seriously concerned about it. The survey revealed that wherever there was extensive new infection, there were also many old cankers bearing the clustered, red fruit-bodies that provide spores in abundance to start fresh cankers. This is evidence of past neglect, and it is of the greatest importance to gouge out these old cankers ; until that is done there is little chance of mastering the disease. There is little gain in painting wounds on apple trees to prevent Canker, for infection through pruning cuts, or where old cankers have been gouged out, is uncommon. The time so spent would be much more profitably employed in cleanly removing more cankers by knife and gouge. Many growers have asked whether the laborious cutting-out process can be eliminated in favour of painting the canker with neat tar oil emulsion or some similar preparation to " burn it out ", that is, to kill the fungus. Experiments have shown that little success can be expected along these lines, and the prompt removal and destruction of young cankers as they arise, thus preventing the accumulation of sources of further infection, is the best remedy known at present. Admittedly the labour problem is acute, but where Canker is ruining many trees the grower must ask himself whether it is not Priority No. 1 in claiming his attention. The longer the job is delayed the worse the problem becomes.

Some growers advocate grassing down to check tree growth and provide a measure of increased resistance to Canker. This is worth doing where other conditions warrant it, for Canker seems to follow strong growth though apparent exceptions to this are sometimes seen. It is noteworthy that young trees planted on old hop land are usually prone to Canker, at least during their juvenile period.

Armillaria Root Rot.—The most noticeable first symptom is the yellow, sickly appearance of the leaves of an affected tree in spring or early summer. Waterlogging at the roots can, however, give rise to a similar condition, the trouble being then usually referred to as " The Death ", so further investigation is necessary to identify the " Honey Fungus ", or " Bootlace Fungus " as it is sometimes called, responsible for Armillaria Root Rot. If the bark near the base of the trunk of a badly affected tree is peeled away, a fan-shaped mat of white fungus tissue, probably containing dark streaks, will be seen underneath. In autumn, clumps of toadstools may arise from the base of the trunk or the ground immediately around it, and when the roots are dug out, strands resembling black bootlaces will perhaps be found among them. By means of these underground strands the fungus spreads from tree to tree and attacks the root system, killing off the feeding roots. A large tree may have been attacked for years before it dies or shows obvious symptoms. The disease is common on trees planted in or near old woodland, and dead stumps are a danger because they, and not living trees, can become infected with spores from nearby toadstools, and can then act as a centre from which " bootlaces " may spread out to the root systems of neighbouring trees. Where the presence of Armillaria is suspected, the grower should seek the advice of his County Horticultural Advisory Officer.

To prevent this disease is easier than to eradicate it when established. On survey, growers were commonly found thinning out orchards by cutting off unwanted trees at ground level and leaving the stumps in the ground, thus providing suitable bases for the fungus to become established and from which to attack neighbouring healthy trees. In existing orchards and adjoining hedges it is most important to grub every unwanted tree as completely as possible.

When planning new orchards on the site of old woodland, Armillaria Root Rot should be borne in mind as a possible danger. Again, it is important that the grubbing be thorough, and it is a good plan to grow an annual crop, such as potatoes, for a few years before the fruit is planted. The frequent soil moving entailed by this crop ensures the maximum disturbance of any bits of tree root, fungus " bootlaces " and such-like left in the soil, and if the fungus does attack the potatoes, as it is able to do, the loss of crop is of small account compared with the possible loss of young fruit trees.

Where an orchard is already affected drastic action must be taken. All stricken trees should be grubbed out and burnt before they die, and the trees in a circle around them should be carefully watched for the first signs of attack. Only by promptly dealing with outbreaks as they arise can the disease be controlled. Because the fungus can exist in the soil for long periods on bits of broken root and on many kinds of plants, affected patches should be clean cultivated and fruit trees should not be planted there again for at least three or four years.

The fungus also attacks poles and spiles used for fencing, staking, etc., so these should all be well creosoted before setting up.

Waterlogging.—Several instances were seen, particularly in heavy land in the Weald. As already mentioned, some of the symptoms are similar to those of Armillaria Root Rot, but with Waterlogging a fungus is not responsible, so that the mat of fungus tissue under the bark, the toadstools in autumn, and the "bootlaces" will not be present. Waterlogging—or "The Death" to give it its popular name—is caused by impeded drainage, and is usually found in heavy land where, during wet periods in autumn and winter, the water cannot get away. A common symptom is the sudden wilting of branches from the tips downwards soon after the trees have started into growth in spring. Spurs and small branches here and there are sometimes affected also. The roots of affected trees are discoloured, and, when freshly cut, often smell strongly of alcohol through fermentation fostered by inadequate soil aeration. Where most of the root system is affected the tree soon dies. Attention to the drainage is the obvious remedy.

A particular form of Waterlogging can occur in trees exposed to strong winds and not properly staked. The wind acting on the head of the tree rocks the trunk to and fro so that the soil immediately around the base of the trunk is panned hard into a crater-like hole, which holds a pool of water in prolonged wet weather. Rotting of the trunk sets in at this soil "collar", and the tree dies because the food supply to the roots is cut off. In such cases the root system will probably be found to be quite sound after the top has died. Firm staking is the remedy, particularly where trees are exposed to high winds.

Brown Rot Blossom Wilt and Canker.—This disease is much more common on farms than might be supposed, and it was encountered frequently on morello and sweet cherries, on plums to a less degree, and on some apples, particularly Lord Derby. Several devastating outbreaks were seen on this variety. Where dead spurs and young shoots, best seen in early June, can be cut out and burnt, this should be done as a first means of destroying the sources of further infection. On big trees, however, cutting out is impracticable. On plums, the fruits are often attacked as well as the flowers, and mummied plums allowed to remain on the trees are another source of infection. Thorough spraying with tar oil towards the end of January (February on apples) is the best means of control, for this spray burns up the fungus cushions that arise on the parts killed the previous year. On these cushions spores are produced that can infect the next crop of flowers. A further aid is a copper spray applied just before the flowers open. If Bordeaux is used, 6 lb. copper sulphate (bluestone) and 9 lb. hydrated lime to 100 gallons water is the recommended strength; any proprietary copper spray used instead should be diluted according to the maker's directions. Lime-sulphur (2 per cent.) can be used, but it tends to retard the opening of the blossoms and to stunt them to some extent.

Bacterial Canker of Cherry and Plum.—This disease was seen in almost all young plum and cherry orchards, and especially in certain varieties.* The dying-back of branches or whole trees during the growing season was often attributed by the grower to unsuitable rootstocks or soil conditions, which can give rise to symptoms resembling Bacterial Canker, but even where it was recognized as a specific disease a remedy was not always known. This disease can be controlled on cherries by two sprayings of Bordeaux mixture each year; one at 10:15:100 just before leaf-fall (mid-October) and another at 6:9:100 just before the blossoms open. Both sprays are essential but their effect cannot be fairly assessed until two years' sprayings have been completed. There is so far no proof that this treatment is effective on plums, and further experiments are in progress to determine the best time to spray them. Summer spraying with Bordeaux mixture (4:6:100) controls the leaf-spot phase of this disease, and, incidentally, Plum Rust as well, but a copper spray alternative to Bordeaux mixture should be used where there is any risk of leaving a visible deposit on the fruit, say, after mid-June. When planning new plantings of plums and cherries it is advisable to seek expert advice, as it is possible to select less susceptible varieties or to embody them as stem-builders for the very susceptible ones.

Raspberry Cane Blight.—A serious dying of fruiting canes in all stages of their development before cropping was frequently seen in plantations of such important varieties as Lloyd George and Norfolk Giant, and this was commonly found to be due to attack by the fungus disease Cane Blight. The fungus causes cankers on the young canes from which, in their fruiting year, spores are produced that can infect the next crop of young canes. Infected fruiting canes easily snap off at the cankers, usually

* The most susceptible varieties are: *Cherry*—Napoleon, Bradbourne Black, Florence, Ohio Beauty, Schrecken. *Plum*—Victoria, Giant Prune, Early Laxton.

near the ground, leaving a snag that remains a source of infection. Cankered canes should therefore be removed and destroyed as far as possible during spring thinning, taking care to sever the cane at ground level or preferably below it. The rows should also be kept free from weeds to promote the circulation of air around the bases of the canes so that the soil does not lie wet for long periods after rain. On no account should young cane for planting be taken from a diseased plantation, and as the disease possibly persists in the soil, it is not advisable to replant immediately with raspberries.

Currant Leaf Spot.—Some severe attacks of this disease were seen. It is caused by a fungus and results in early defoliation of the bushes. It attacks currants, particularly blacks (Baldwin is very susceptible), and gooseberries. It can be recognized by the presence of scattered, angular, brown spots on the leaves in the summer. Badly affected leaves soon turn yellow and drop. Spraying with Bordeaux mixture (4 : 6 : 100) is the best remedy, but because this leaves an unsightly deposit on the berries, picking should be finished before the spray is applied. In wet summers, however, the disease can be so severe before picking that the berries shrivel on the bushes from lack of leaves. Where the disease appears regularly and early, therefore, the bushes should be protected by spraying in advance of infection, and some weeks before picking, with a copper preparation (e.g. " colloidal " copper) that will not leave a visible deposit on the berries. A few growers had tried copper-lime dust in June, and averred that this had checked the disease. Dusting, however, stands little chance where the disease is already firmly established.

Summary.—A brief account is given of the following diseases seen during the fruit survey of Kent : Apple Scab, Pear Scab, Apple Canker, Armillaria Root Rot, Waterlogging, Brown Rot Blossom Wilt and Canker, Bacterial Canker of Cherry and Plum, Raspberry Cane Blight, and Currant Leaf Spot ; and remedial measures are outlined.

A NOTE ON APPLE SUCKER

By A. M. MASSEE

The Apple Sucker (*Psyllia mali* Schr.) is not regarded as an important apple pest by most fruit-growers these days ; nevertheless it still persists quite commonly in many parts of Kent where winter washing is not carried out as a matter of routine. It is most prevalent on small holdings and on arable farms where there is a small patch of fruit, generally known as the home orchard, that is kept rather as shade for cattle in the summer months, than for the fruit it may produce.

During the course of survey work during the past two seasons severe outbreaks of Apple Sucker have been noted in the Edenbridge district, Halstead, Otham, Canterbury and Cranbrook, and on many of the small fruit areas along the North Downs in Kent.

The Apple Sucker is a very destructive insect and invariably destroys the whole of the blossom trusses unless it is kept under control by spraying.

The Apple Sucker hatches from an elongated, pale straw-coloured egg in the spring at the green cluster stage of the buds. The immature Sucker is yellowish-white, with brown legs and red eyes. It enters the trusses and feeds on the sap. It excretes from the apex of its body a sticky globule and waxy threads, which are usually white, but may be iridescent. The infested trusses also become sticky and discoloured. At this state the immature Sucker moults and its colour becomes apple green. In the field the Sucker is not usually detected until the tree is in full flower and by this time much of the damage has been caused and the flowers fall off prematurely or are malformed.

The adult Apple Sucker is winged and is an eighth of an inch in length. It occurs from the end of May until November, and lays its eggs at random on the buds and spurs in groups of some hundreds. The egg stage persists throughout the winter, and the nymphs hatch out the following April.

The Apple Sucker can be controlled very effectively by spraying with a 5 per cent. tar distillate winter wash in December, January or in February, care being taken to cover the whole tree because the eggs may be deposited anywhere from the main trunk to the tips of the topmost branches.

In orchards where a winter wash has not been applied it is possible to obtain adequate control by spraying with nicotine in the spring provided the wash is applied at the correct period. It should go on between the green cluster stage and the pink bud stage. It must be emphasized that it is too late to wait until the pink bud stage because by that time serious injury will have been caused to the blossom trusses. The spray should be applied at a pressure not less than 300 lb. per square in., and should be directed into the flower trusses. A spreader should be added. The nicotine is most effective when applied alone, but if lime-sulphur and lead arsenate are being applied to control other diseases and pests, then the nicotine may be added to the other sprays. The nicotine should be used at a strength of 8 oz. to 100 gallons of water.

Summary.—Measures for the control of Apple Sucker are briefly described.

THE MERITS OF THE NEW VARIETIES OF HOPS

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As economic events, market requirements, and growers' standards alter, so the varieties of farm and horticultural crops come and go. In a single lifetime, for instance, the commercial varieties of potato and raspberry have completely changed. Such factors as disease resistance and cropping capabilities, shape or attractiveness, and cooking or preserving qualities have played their part as a specialized demand has grown with the increase of technical knowledge. So, too, with hops. Where are the Tolhursts, the Colgates and even the Tutshams? And what of the troubles menacing the "Fuggle" and "Golding" varieties of the moment? Some thirty-five years ago Professor Salmon at the S.-E. Agricultural College, Wye, set out to see whether he could raise new varieties combining the merits of the much sought after Saaz and Oregon varieties and capable of yielding heavy crops of high quality under English climatic conditions. For the first time hybrids were raised between the European hop *Humulus Lupulus* and the American species or sub-species, *H. americanus*.

Every plant breeder knows that his will be a long and painful road and that for every good new variety many hundreds must be tried and discarded. After passing through the nurseries at Wye the best of the new varieties have been sent for the past twenty-five years to East Malling Research Station to be put through a field test. Here the growth characters, season, cropping performance and susceptibility to disease were studied over a further period of years and, if they passed this scrutiny, sufficient hops of each variety were dried for analysis of the resins and for small sample pockets for brewing trials.

While some of the most promising new varieties, such as M45, have already been discarded owing to some latent defect, at least five of them, considered worthy of naming by their raiser, have found their way into commercial hop gardens and to-day growers are asking for an ever increasing number of sets. Growers have learned how to handle them and how to grow good samples of them and in the past season such samples were realizing prices equal to the best Goldings, while the new varieties are giving a much higher yield per acre. When the value of their high resin content and performance in brewing are fully understood, they may prove even more profitable to grow.

Before briefly describing the merits of these new varieties, it should be stated that, like the commercial variety "Fuggle" and many male hops, they are potential carriers of Mosaic virus disease to susceptible "Golding" and other types. While they themselves tolerate the disease they are possible sources of infection to Goldings and should only be planted by themselves or adjacent to the "Fuggle". Until more is known about the spread of Mosaic disease it is for safety recommended that the new varieties should be isolated from Golding gardens by a mile.

Detailed descriptions of these varieties have already been published by Professor E. S. Salmon (15, 16, 17), whilst their performance from year to year has been given in the twenty Annual Reports on the New Varieties of Hops at East Malling Research Station (6th-25th Reports on the Trial of New Varieties of Hops, 1922-41). All the five varieties have proved consistently richer in P.V.* than the ordinary English varieties, and two of them equal or superior to the richest American growths. Particulars of the P.V. of the five named new varieties, together with that of Fuggles, Golding and American growths for the period 1935-39 are given in the Table. Finally some fourteen reports on brewing trials with these varieties have been published from time to time in the *Journal of the Institute of Brewing* by eight well-known authorities (1-14). The following notes therefore attempt to summarize this mass of information for the intending grower.

Brewer's Favourite (ref. No. OP21) was raised in 1909. It was the second generation from the American variety Oregon Cluster, its male parent in each generation being an English hop. It was named Brewer's Favourite in 1934 and is now being grown experimentally in a few commercial hop gardens.

Whilst in growth it appears weak early in the season and the hills do not produce many shoots, later a quantity of strong and very fruitful laterals bear a mass of pale green cones. These hang free from small leaves and part very readily from their stalks—an ideal "pickers' hop".

In season Brewer's Favourite is about ten days later than Fuggle. It has cropped well at East Malling ever since it was planted in 1919, and the average yield from an experimental half-acre from 1934-41 has been nearly 21 cwt. per acre. Reports of its cropping elsewhere are equally good.

Whilst it is more susceptible to Downy Mildew than many varieties, being similar in this respect to such varieties as the Bramling and the Goldings, the disease has been quite readily controlled at East Malling and Wye College by the regular pre- and post-burr applications of Bordeaux at the

* P.V. = Preservative Value.

optimum time. However, this variety should not be planted up except by those fully equipped to deal with Downy Mildew.

In its resin content and preservative value it has proved consistently richer than any English commercial variety. It is not usually so rich as some of the other introductions but the analysis of a Maidstone growth (1942) gave 6·47 per cent. α and 9·56 per cent. β resins.

A well managed sample presents an attractive side; in most seasons a slight, though not unpleasant, Oregon aroma can be detected.

Between 1925 and 1932, numerous brewing trials at a number of representative breweries have been reported upon (8, 9, 12, 13), and since then the growths have been readily purchased by a number of firms. Whilst the reports have varied somewhat under different conditions, Brewer's Favourite has been compared favourably with a good British Columbian hop; it has generally been considered a suitable copper hop producing beer of good flavour and keeping quality, and when used as a dry hop has given "a delicate pleasant flavour". In two series of trials its strong flavour was emphasized (11), but in some laboratory brews it was claimed to be "almost as good as Goldings" (2). Finally in 1932, "the unanimous decision (of eight brewers) was that Brewer's Favourite was a perfectly satisfactory copper hop and an excellent dry hopper" (3).

Quality Hop (ref. No. OO63) was raised in 1919. It was the third generation from the Oregon Cluster through two promising seedlings (M45 and OP13), and an English male parent. It received its name in 1936 and is now being grown experimentally in a few commercial gardens. Under East Malling conditions it behaves in growth like the Fuggle. It starts with a quantity of vigorous shoots but slows down towards midsummer and produces little head and moderate lateral growth. The vivid green cones are crowded on the upper and shorter laterals but hang more separately on the longer and lower ones. The cones hang free from the leaves and are easy to pick. Quality Hop is slightly later than the Fuggle and hangs extremely well without showing signs of "going off".

It has been a reliable cropper at East Malling since 1929 and the half-acre planted (7 ft. × 7 ft.) in 1935 has cropped at the rate of over 17½ cwt. per acre. Its habit of growth would allow of slightly closer planting, say 6 ft. × 6 ft., which would probably increase the yield considerably.

Quality Hop is not particularly susceptible to Downy Mildew.

It has been several times reported upon as having "a good stout side, pleasant flavour" and "fine hop, rich in resin, good nose"; in some seasons a mild American aroma can be detected.

Physical examination at once shows the extreme richness of the cones, the very numerous petals being abundantly supplied with lupulin glands, and it has in fact proved the richest of the new varieties of non-Manitoba origin as yet introduced to commerce. Brewing trials in 1934 (4) showed that it gave a pleasant flavour and normal bitter when used at the rate of 1·49 lb. per barrel and that it was suitable for pale ales. In recent trials this variety has been highly commended as a dry hopper.

Fillpocket (ref. No. Z62) was raised in 1919, and received its name in 1936. It is another second generation seedling from the Oregon Cluster via M45. It is being grown experimentally in a few commercial gardens. At East Malling and at Wye the hills provide an ample supply of shoots in spring, subsequent growth is slow but as soon as the bine reaches the top the development of the cones, on long laterals, is rapid. The cones are pale green and tightly closed. They are firmly attached to the bine and are not so easy to pick as those of the two foregoing. In season, Fillpocket is midseason-late.

On somewhat shallow soil over chalk at Wye, the variety has given heavy yields estimated at 20-25 cwt. per acre. On the "hotter" land at East Malling the yields have been disappointing, the quarter-acre planted in 1937 has cropped on the average at just over 16¼ cwt. per acre from 1939 to 1942. In the Fuggle district of Marden this variety has recently cropped at the rate of 25 cwt. to the acre. Though it is subject to the "spike" form of Downy Mildew there is plenty of bine in the spring and the cones seem definitely resistant to attacks of this disease.

It is considerably richer in resins than ordinary commercial English growths, coming between Quality Hop and Brewer's Favourite.

Samples have been reported upon as having "very stout side, good flavour" and "thick buttony hop".

In brewing trials (4) it was used in the copper at 1·81 lb. per barrel, and was reported to give a strong but pleasant flavour and to be suitable for pale ales.

Brewer's Gold (ref. No. C9a) was raised in 1919 by crossing a wild hop obtained from Manitoba with an English male. It was named in 1934, and is already being grown in twelve commercial gardens on an increasing scale.

At East Malling trained on the Butcher system, growth appears somewhat weak early in the season and the bines are few. Later very strong laterals are produced which cross on to and climb up neighbouring strings and thus form a solid wall of growth. Where high wirework (14 ft.) is used, with the "umbrella" system of training, very fine growths of Brewer's Gold are being produced.

Summary of P.V., 1935-39.

New Methods of Estimating P.V.; 10α.

	Bullion Hop Q43.	Brewer's Gold C9a.	Quality Hop 0063.	Fillpocket Z62.	Brewer's Favourite OP21.	Fuggle.	Rodmersham Golding.	Richest American.
1935 ..	—	107	86	68	76	68	—	75
1936 ..	99	90	84	80	70	53	—	90
1937 ..	120	113	53*	63*	56*	58	—	85
1938 ..	95	99	78	63	61	65	49	83
1939 ..	102	95	73	75	70	61	68	90

* Late analysis and therefore low resins.

Old method of Estimating P.V. $(\alpha+\beta/3) \times 10$.

1935 ..	—	149	125	108	113	94		135
1936 ..	142	138	118	125	107	102		121
1937 ..	165	160	111	109	99	91		129
1938 ..	142	145	111	97	97	82	73	134
1939 ..	149	129	109	113	107	97	97	119

Under conditions where vigorous growth is obtained as at Wye and at East Malling, it has been found best to train up only a single bine to each string. On mature hills, the cones are only medium in size and there is a tendency for small " fluffy " under-hops to be produced rather hidden amongst small leaves—this, with the tangled laterals, renders picking rather difficult. This is largely compensated for by the few bushels of green hops (about 95) needed to give a cwt. of dried hops. It is a true late variety and should be left till last.

It is an extremely heavy cropper and at East Malling has yielded at the average rate of $25\frac{3}{4}$ cwt. per acre over a 14 year period. This is partly due to the fact that it " weighs well ".

Brewer's Gold is not particularly liable to attacks of Downy Mildew either on the bine or cones, and clean crops can easily be grown with the usual Bordeaux sprayings. It has been known to contract Nettlehead virus.

Over a long period of years analyses have shown Brewer's Gold " to be on the average richer than the best American growths available ", and of course greatly to exceed in P.V. any of the older varieties. The variety has a non-English aroma now characterized as " Manitoba ". Though many brewers object to this, others are buying the growths freely, as it has been shown that this " American " aroma does not pass into the beer, which has a fine flavour. In a recent laboratory trial (14) with several new varieties it was reported, " In no case was the peculiar aroma associated with the hops of the Manitoba (lower fatty acids) and New Mexican (terpene like) parents detected in the finished beers," and in answer to the question : " How do the beers compare with that brewed with Oregon hop alone ? " the majority of the new varieties were preferred to the control which produced rather a rank flavour.

A considerable number of brewing trials in many districts have been carried out with Brewer's Gold from 1931 onwards (1, 2, 4, 5, 10). Since both Brewer's Gold and Bullion Hop (see below) are so much richer in resins than hops normally used, the trials brought out the fact that these hops, like some imported American varieties, should be used at a lower hop rate, or wastage occurs and rank flavour with excessive bitterness may result. However, as these facts became appreciated the hops were tried in smaller quantities of 14 oz. and even 10 oz. per barrel, and the beers were pronounced very pleasant as regards aroma, flavour and bitterness (6). This hop is now in considerable demand.

Bullion Hop (ref. No. Q43) is a sister seedling of Brewer's Gold, though it was not named until 1938 (17). It is now being grown in a few commercial gardens. Though very similar in growth to Brewer's Gold, the cones are larger and firmer and less hidden amongst small leaves. It is therefore easier to pick. It is a late mid-season variety ready a week or ten days before Brewer's Gold. It has proved an extremely heavy cropper and over an eight-year period at East Malling has yielded at the rate of nearly 26 cwt. per acre. It appears to improve in cropping with age. Like her sister, Bullion Hop " weighs well ". It has not been particularly susceptible to Downy Mildew either at Wye or East Malling and has so far not exhibited any other failings. It is extremely rich in resins, usually being slightly richer even then Brewer's Gold. Bullion Hop is very definitely of the " Manitoba " type and has a strong American (" Manitoba ") aroma.

Brewing trials (5, 7) have been carried out for several seasons, and it was reported in dry hop tests that less than 2 oz. per barrel is required. Above this the brew became too bitter. Used as a copper hop at 1·3 lb. per barrel it proved rather bitter but had no unpleasant flavour. Later trials (7) showed that after fourteen days the beer had " a fragrant aroma and good taste ", though when tested new was " unpleasant ". The final conclusion was drawn that Bullion Hop could be used safely in brewing pale ales provided it was used under suitable conditions of brewing and in proper proportions.

There is doubtless much still to be learned about the use of these outstandingly rich and heavy cropping hops, but it is clear that both Brewer's Gold and Bullion Hop could be used to replace imported American hops with no loss but rather gain to the brewer.

The problem of disease resistance is becoming more urgent every year, and it is very possible that from amongst the new varieties selections resistant to the Verticillium Wilt disease may be forthcoming. Hence the encouragement of all interested in hops should be continually extended to this work of breeding, testing and selection which has already yielded at least five varieties worthy of commercial cultivation.

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INDEX

Alpha naphthalene acetic acid, use of, 20, 47
Analysis, spectrographic, 21
Aphides, 24, 67
Aphis transmission of Strawberry Crinkle, 25
Apple Blossom Weevil, 24, 64
——— ——— ———, control experiments, 24. 26
——— Canker, control, 27, 105
——— Capsid, timing of winter sprays, 26
——— frog hopper on, 66
——— Fruit Rhynchites, 64
——— Leaf Skeletonizer, 65
——— plantations, experimental, 96
——— rootstocks, 14, 91
——— ———, anatomy of, 14
——— ———, methods of propagation, 84
——— Scab, 104
——— ———, control by phenyl mercury chloride, 26
——— ——— ——— by sulphur sprays, 26
——— ——— ——— by tetramethylthiuram disulphide, 26
——— ———, influence of manuring on, 27
——— ——— ——— zinc sprays and injections, 27
——— Sprays to prevent pre-harvest fruit drop, 20, 47
——— Stalk-end Rot, 24
——— Sucker, 107
——— Sun Scald, 17, 27, 50
——— varieties and classification, 16
——— Winter Moth, 25
Apples, acreage and cropping, 11
———, frameworking, 17, 18
———, reworking, 18
Apricot Brown Rot, 22, 24
Arable Crops, 13
Armillaria Root Rot, 105
Arsenate-lime-sulphur damage on apple, 26

Bacterial Canker, trial for control of, 53
Bactericides, 26
Bacteriosis of plum and cherry trees, 22, 26, 27, 53, 61, 106
Bark grafting, 17
Biennial bearing, 15
Black Currant Leaf-curling Midge, 25
——— ——— Reversion, 25
Black Currants, 11, 12, 16, 18
——— ———, nuclear stocks of, 12, 91
——— ———, seedling, 16
Breeding, new raspberry seedlings, 31
——— new rootstocks, 14
Broad Mite, 67
Brown Rot, 22, 24
——— ——— Blossom Wilt and Canker, 106

Carrot Black Rot, 24
Cereals, acreage and cropping, 13
Cherries, acreage and cropping, 11
Cherry bacteriosis, 22, 27, 61, 106
——— rootstock trials, 14
——— rootstocks, propagation of, 85
Clay Coloured Weevil, on hops, 64
Cover-cropping, 15
Coxcomb Prominent Moth, 65
Crop estimation, 97
—— recording, 19, 36
Cultural Treatment of experimental plantations, 97
Currant Eelworm, 67
——— Leaf Spot, 107
Cuttings, propagation from, 14, 20, 88

Derris, trials of substitutes for, 26
Dinitrocresol (D.N.C.) sprays, 13, 26, 27
Double-working, 15
——— stembuilders for plums, 53
Dual purpose winter washes, 26, 27

Earwig, on hops, 67
Etiolation, 41, 87
Experimental apple plantations, cropping of, 96
——— design, 19
——— nurseries, 11
——— orchards, 11

Fertilizers, inorganic, 15
Frameworking, 14, 15, 17, 18
——— for pollination, 11, 15, 100
Frog Hopper, on apple, pear and hop, 66
Frost Damage, 11, 18, 97
Fruit farm census, value of, 93
——— diseases seen on survey, 104
——— planting policy, 90
——— size, estimation of, 38
——— surveys, 19, 30
——— tree certification, scheme for, 93
Fungicides, field trials, 26
——— laboratory tests, 25

Grafting, 17
Gall mites, 68
Grey Mould, 23, 24
Grass orcharding, 15
Growth substances, 20, 44
——— ———, spraying to prevent pre-harvest fruit-drop, 20, 47

Hoeing, 103
Hops, acreage and cropping, 12
——, Armillaria disease, 29
——, Clay Coloured Weevil on, 64
——, commercial varieties, 27, 75
——, comparison of sets and cuts, 73
——, cultural trials, 28, 70
——, earwig on, 67
——, Fluffy Tip disease, 29
——, frog hopper on, 66
——, insect pests, 29, 30
——, manurial trials, 28
——, Mosaic disease, 29, 82, 108
——, Nettlehead disease, 29
——, new varieties, 27, 29, 108
——, number of bines per string, 70
——, Phytophthora disease, 29, 62
——, propagation trials, 28, 73
——, P.V., 12, 80, 108
——, Split Leaf Blotch, 29, 77
——, Stopping, 70
——, Verticillium Wilt, 28, 30
——, Virus Diseases, 29

Inarching, 15
Incompatibility, 15, 56
Injection, 21
Inorganic fertilizers, 15
Insecticide trials, 26
Irrigation, 15, 17, 103

Lacewing bug, 25, 66
Layering, 20, 87
Leaf cutting bee, 66
—— scorch, 15, 22
—— hoppers, 24

Loganberries, 11, 12, 16
————————, nuclear stocks of, 12, 91
Loganberry Cane Spot control, 27
Low temperature injury, 15, 18

Manuring, 15
Manurial programme in relation to Apple Scab, 27
Manuring of fruit and vegetables, 19
Marbled Carpet Moth, 64
Meteorology, 17, 18
Mineral deficiencies, 20, 21
" Modified Edgar " method of recording, 39
Morello cherry bacteriosis, 61
Moths, 64, 65

Nicotine, vaporized, 24
Northern Drab Moth, 65
Nuts, 17

Oil sprays as ovicides, laboratory tests, 25
Organic compounds as fungicides, laboratory tests, 25
Ovicides, 25

Peach Bacterial Canker, 22
——— Sun Scald, 17, 27, 50
Pear Scab, 105
—— Blossom Blight, 22
——, frog hopper on, 66
Pears, acreage and cropping, 11
——, sprays to control pre-harvest drop of fruit, 47
——, varieties and classification, 16
Phenomenal Berries, 16
Phenyl mercury chloride, trial for Apple Scab control, 26
——— ——— ——— ——— Potato Blight control, 26, 68
Phytophthora Disease of hops, 62
Plant analysis methods, 21
—— extracts as fungicides, laboratory tests, 26
Plants and their water supply, 19, 103
Plum Aphid, Mealy, 67
—— bacteriosis, 22, 26, 53
—— Gall Mite, 68
—— rootstocks, propagation, 14, 20, 84
—— ————————, wilting of shoots, 22
—— Rust, 59
—— Sawfly, 66
Plums, acreage and cropping, 11
——, frameworking, 17
——, stem-builders, 54
——, time of pruning, 54
Pollinators, 15
————————— in experimental plantations, 98, 100, 101
Potato aphid, 67
——— Blight, phenyl mercury chloride trial for, 26, 68
Potatoes, acreage and cropping, 13
Pre-harvest drop, spraying for, 20, 47
Propagation, 14, 20, 84
————————— by hardwood cuttings, 14, 20, 40, 88
————————— by root cuttings, 88
————————— of small fruits, 90
Pruning, 15
——— of experimental plantations, 97
———, time of, on plums, 54

Quince rootstocks (for pears), propagation of, 84, 85
——— ————————— ————, double-working on, 15

Raspberries, 11, 12, 16
————————, cropping trial, 16
————————, nuclear stocks, 12, 91
————————, seedlings, 16, 31
————————, varieties, 16, 18
Raspberry Beetle, 26
————————— Cane Blight, 33, 106
————————— leaf curl disease, 23, 48
————————— Moth, 64
————————— virus diseases, 22, 91
Records, 19
Red Spider, 67
Root distribution of cover crop plants, 15
Rootstock stoolbeds, 11, 12, 84
Rootstocks, for tree fruits, 14, 84, 91
————————, crop per acre, 89
————————, propagation of, 84, 91
Rubi, diseases of, 25

Sampling, 19, 36
Soil moisture, 15, 103
Spectrographic analysis, 21
Spray damage investigations, 26
——— ——— in plums, 59
Spraying in bloom against Apple Scab, 26
————————— for control of Bacterial Canker in Plums, 57
————————— programme, 13
————————— for prevention of pre-harvest fruit drop, 47
Stem-builders, 54
Stoolbeds, 11
Stooling, 87
Strawberries, acreage and cropping, 11
————————, carrier varieties, 16, 23, 90
————————, cultural trials, 16
————————, irrigation, 17
————————, liming, 16
————————, making the most of a limited acreage, 18
————————, propagation, 12, 90
————————, runner beds, 12, 90
Strawberry Aphis, 24, 25
————————— ——— vaporized nicotine treatment, 24, 91
————————— Crinkle, 24, 25
————————— frost damage, 11
————————— Leaf Blotch, 23, 24
————————— Tarsonemid Mite, 25
————————— virus diseases, 23, 24, 90
————————— Yellow-edge, 23, 24
Stub grafting, 17
Sulphur sprays, trial for Apple Scab control, 26
Sun Scald of fruits, 17, 27, 50

Tarsonemid Mite, 25
Tetramethylthiuram disulphide, trial for Apple Scab control, 26
Thiocyanates as substitutes for derris, 26
Topworking, 18
Tremelloid outgrowths in fungal cultures, 24

Variation studies, 19
————————— in weight of apples, 37
Vectors, 25

Walnuts, 17
Watercress Beetle, 64
Waterlogging, 106
Water supply of plants, 19, 103
Weather conditions during 1941, 19
————————— ————————— ——— 1942, 11, 33
————————— ————————, effect on fruit production, 97
Winter injury, 15, 18, 19
——— Moths, 65
Woolly Aphis, rootstocks immune from, 14, 16

Zinc sprays and injections, influence on Apple Scab, 27